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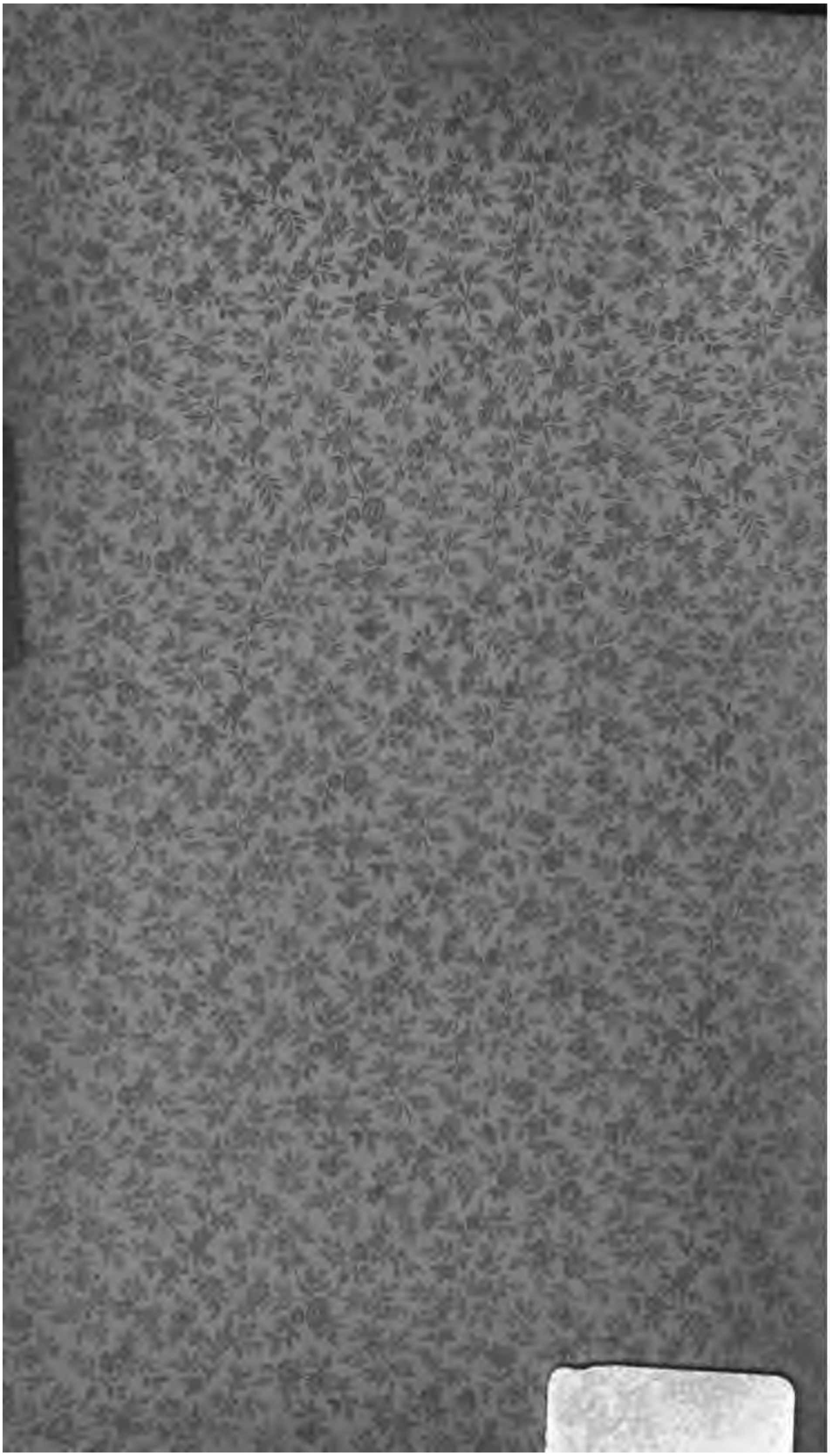
Twenty-sixth Convention
Chicago, Illinois
May 26, 27, 28, '03



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Louis A. Ferguson

NATIONAL
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TWENTY-SIXTH CONVENTION

CHICAGO, ILLINOIS
May 26th, 27th, 28th, 1903

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63—Have any members had trouble through the breaking of glass battery jars at the time of, or soon after, removing the sediment from such jars when a wooden scoop is used? Is there any way to prevent such an occurrence?—36, 150.

64—What methods have been used to provide fairly uniform temperature and proper ventilation for storage battery of given capacity, and how often is there a complete change of air?—36.

65—What is the best method of enabling an operating superintendent in a large system to keep track of the changes in load and conditions in a large number of stations, transmission lines and substations?—130.

101—What is the best and simplest method of erecting large poles?—29, 35 50, 93, 122, 152.

102—Is a single-phase, two-phase or three-phase distribution best adapted for lighting in cities of from 15,000 to 50,000 population?—5, 35, 68, 97, 130, 130, 152.

103—Has the 220-440-volt, three-wire system proved successful and satisfactory in operation? Please state troubles experienced as well as benefits derived.—5, 97, 111, 121, 142.

104—How may the swinging lead wires from cross-arms to arc lamps be prevented from breaking?—45, 52, 64, 73, 77, 79, 83, 98, 108, 122, 125, 141, 150.

105—What is the best method of protecting wires, carrying current of 1000 volts and upward, from grounds on trees through which they must pass?—5, 12, 35, 73, 81, 103, 126.

106—What is the best protection for telephone lines strung on poles carrying high-tension circuits, or on separate poles at such distance from high-tension poles that there is a possibility of high-tension wires falling or being blown upon the telephone wires?—5, 35, 103, 125.

107—What is the best method of protecting transformers, etc., from lightning and other static strains on long-distance transmission lines?—30, 35, 58, 69, 87, 97, 111, 149.

108—What is the latest practice for prevention of explosion of lightning and sewer gas in conduits?—5, 22, 35, 84, 93a, 130.

109—In a 10,000-volt line—15-mile line over mountain country—our banks of arresters keep continuously hissing when lines are hot. They did not hiss last year, but do now. Why? Arresters also will hiss when not attached to ground wire. Why? We also note that building up arresters from four to five blocks makes no difference. Why?—8, 69, 103, 111, 121, 149.

110—In an alternating-current station equipped with three-phase generators, is it not better to run all lighting load on one phase and adjust voltage of this phase to suit the lighting circuits, paying no attention to either of the other phase voltages and using the three phases for power work only, buying machines designed to handle the load in this way, rather than to attempt to balance lighting load on all three phases and adjust the three-phase voltages to suit load?—5, 17, 35, 68, 73, 97, 125, 152.

111—In a plant of 3000 lights' capacity, single-phase, 60-cycle, primary 1040, secondary 104, seven and one-half miles pole line, 250 consumers,—what in good practice would be the loss, from the station switchboard to the consumer's meter? Plant furnishes current for lights only; run from dusk to dawn.—5, 35, 38, 47, 56, 64, 68, 97.

112—What is the best method of locating grounds on an Edison three-wire underground network system?—5, 93, 104.

113—What would be the best and cheapest method of underground wiring for a small town?—5, 22, 35, 84, 93, 128.

114—What has been the experience in operating an alternating-current system of from 1000 to 2000 volts in conduit that is more or less filled with water?—35, 87, 128, 136.

115—What remedy should be applied to overcome the humming of telephones, caused by series alternating arc-light circuits?—21, 47, 48, 126.

116—What has been the experience in making service connections with underground alternating-current system; particularly with regard to use of fuses in junction boxes, location of transformers in manholes, and detail methods of secondary distribution?—22, 35.

117—Can a system of remote control be installed on a number of alternating current lighting circuits where transformers are banked and network distributing system used, cutting out the surplus transformer for day load; investment on system to show saving over core loss?—5, 35, 100.

118—Is it advisable to ground secondaries at the transformer or in the buildings supplied?—5, 35, 85, 104, 105, 108, 125, 132, 136.

119 What is the weight per kilowatt capacity and the cost per kilowatt capacity of the Cooper Hewitt static converter?

120—What is the best transformer fuse box for 2000-volt alternating-current, and why?—23, 47, 77.

121—What is the advantage to an alternating-current station in carrying a secondary voltage much in excess of 100, unless it has an extensive system of secondary mains?—35, 47, 56, 64, 85, 97.

122—What is the consensus of opinion regarding tying in secondary wires from different makes of transformers? Have central-station managers adopted the practice generally, and with what results?—5, 35, 47, 52, 73, 103.

123—How far from a central station would it be practical to extend the Edison direct-current system, using the regular low voltage—110 or 220 volts—and where would it be desirable to install the alternating system?—5, 22, 35, 68, 72, 97, 147.

124—Which would be the more economical: to distribute on the alternating-current system, or to install a substation with rotary transformers?—5, 22, 35, 97.

125—Would there be any difference in the liability insurance rates as between the high and low-tension systems?—5, 92, 104.

126—How often should meters be tested?—5, 11, 19, 35, 38, 47, 72, 87, 88, 119, 126, 136, 150.

127—Should meters be tested in place, or should they be returned to the station for the purpose?—5, 11, 19, 35, 38, 47, 65, 72, 73, 87, 88, 108, 119 126, 133, 136, 150, 152.

128—What degree of accuracy in a meter under test at five per cent of its rated load should be allowed to pass without further adjustment?—5, 11, 19, 35, 47, 72, 88, 119, 136.

129—What efforts, if any, have been made to introduce any form of prepayment meter?—5, 35, 46, 87, 88.

130—Is it good practice for central stations to furnish wattmeters free in small towns?—11, 46, 52, 64, 65, 73, 83, 88, 108, 126, 136, 145, 147.

131—What proportion of plants in the different states has adopted the inclosed-arc lamp for street service?—5, 35, 57, 82.

132—Is it best practice to omit outer globes of inclosed-arc lamps for street lighting, provided the inner globe is protected from the weather by a metallic shade, the same as usual when outer globe is used?—5, 35, 38, 52, 73, 98, 129.

133—Is there any known remedy for the humming of multiple alternating arc lamps?—5, 35, 52, 56, 82, 98, 121.

134—Is it desirable, from the electric-light company's standpoint, to advise the use of the so-called "turn-down" lamps by consumers? Will the advantage of advertising to the general public offset the corresponding loss of current due to the fact that the majority of meters in use will not register on the small filament on turn-down lamps?—5, 12, 35, 46, 47, 63, 65, 72, 87, 89, 146, 147.

135—What system is mostly used to check up lamp manufacturers' guaranteed life and general efficiency?—35, 45, 62, 87, 99, 146.

136—What is the best incandescent lamp base to adopt, and why?—5, 35, 38, 47, 48, 63, 72, 73, 99, 146, 150, 152.

137—In the latest type of Edison lamp there is no place suitable for stamping the date of delivery to customers when free renewals are furnished. Would it not be advisable for the manufacturers to have blank labels pasted on for this purpose?—35, 38, 52, 72, 99, 113, 146.

138—What has been the experience in electric heating in a small way?—5, 87, 89.

139—What has been the experience in operating single-phase motors on lighting circuits?—35, 45, 47, 59, 65, 103, 105, 136, 150.

140—To what sizes is the operation of single-phase motors on lighting circuits practically limited?—35, 45, 59, 103, 136, 150.

141—What is the best method to pursue where the starting current of an induction motor is so far in excess of the running current that a fuse which will hold the starting current will not protect the motor?—5, 14, 35, 73, 85.

142—What is the best method of operating electric elevators on an alternating-current system: one, two, or three-phase?—5, 35, 76, 100, 136.

143—What has been the experience of small lighting plants that are furnishing current for electrically-driven pumps in city water-works? Has it been found to be profitable?—10, 109.

144—Would it pay to operate a single-phase, 5-hp motor for pumping, to replace a steam pump that is run for an independent boiler requiring a man in attendance? Company that owns pump, owns lighting plant.—35, 47.

145—What is the best method of preventing or mitigating the bad odor from exhaust steam used for heating purposes?—102, 105, 145.

146—Which is the better system to use for street lighting in small towns of 1500 to 3500 population: the multiple alternating arc or the series alternating arc, and why?—26, 35, 43, 77, 83.

147—What would be the best system for a central station to adopt for reaching a town five miles away from station, with a load of about 30 kilowatts on primary for lighting purposes? The station is equipped with two-phase, 60-cycle, 2200-volt alternators. Should a line be run from station at generator voltage, or should step-up transformers be used?—26, 35, 43, 45.

148—In power-transmission plants operating on three-phase alternating-current system limited to 1000 feet distance, the maximum lighting load being 25 per cent of the maximum power load, which is the better system—220 or 440 volts?—35.

149—Has the 110 and 220-volt, three-wire system, with constant-potential street arc lamp current returning on the same neutral wire as the commercial light current, proved satisfactory? If not, what is the trouble experienced?—35, 147.

150—Should high-voltage wires be strung over or under other wires, and how much clearance should be allowed?—35, 83.

151—To prevent danger to linemen and troubles from induction, what should be the minimum vertical distance between the high-tension wires (1000 to 2000-volt) of two different companies occupying the same side of the street or crossing at right angles?—35, 83.

152—In a monocyclic system with 7300-volt feeders, stepping down to 2200 volts for distribution, should there be a separate system of power mains, or should the power and lighting transformers be connected to the same lines?—35, 56.

153—What size of wire is required to operate seventy-five 60-cycle, constant-current, 7.5 ampere, series alternating arc lamps with 73 volts at arc, on a circuit 18 miles long?—56.

154—Are the present strain insulators for guying safe for from 4000 to 9000 volts?—26, 35, 36a, 53, 112.

155—Does it add to the danger to linemen working on overhead lines to ground the neutral on 2300-volt primary circuits?—104.

156—What method of grounding lightning arresters and transformer secondaries gives the best ground at the least cost?—45.

157—What is the ratio of transformer capacity to connected load for (*a*) residence lighting, and (*b*) business lighting?—20, 45, 126, 136, 150.

158—In what way can a test be made for finding the efficiency of transformers in place? How can such transformers be tested for aging? How should a record be kept?—7, 35, 69, 112, 116, 138.

159—What is the best method of locating fuse blocks on a primary distributing system?—136.

160—What form of primary fuse is found to give the best results?—56, 150.

161 What kind of fuse cut-out is best adapted for 2200-volt circuits?—56, 136.

162—What has been the experience in the use of single-conductor, lead-covered cable for single-phase and polyphase underground work?—56, 136.

163 Can single-conductor, lead-covered cable be used for high-tension, three-phase generator leads when length of leads does not exceed 1000 feet, and the cable is drawn through three separate ducts of clay conduit, the separation of leads being four inches?—35, 53, 69.

164 What has been the effect of burnouts on concentric cable as compared with burnouts on single-conductor cables?

165 In some of the eastern cities it has been the practice, where cables are used on mains and feeders, to connect the cables together solid at street intersections, instead of using fuse junction boxes as employed on

Edison tube work. Have any serious burnouts occurred on such cable mains, and do you think the extent of damage done would have been less if fused connections had been employed at street intersections?—35, 36a.

166—Have you had any trouble with oil switches failing to open circuits in case of trouble due to short-circuits or other causes?—35, 130.
(NOTE.—Questions 166, 167, 168 and 169 refer to circuits operating at 6000 volts or more from stations having several thousand kilowatt capacity in generators.)

167—Have you had any burnouts on high-tension transmission cables, and if so, how were they caused, and how much damage was done?—35, 130.

168—What method do you use for protecting high-tension transmission cables from manhole fires?—35, 130.

169—Have you had any trouble caused by stray currents flowing on the lead sheath of transmission cables, and do you use any method for breaking the continuity of the lead sheaths on these cables?—35.

170—What should be the per-cent drop in voltage on a well-equipped alternating-current line between station and centre of distribution?—35, 45, 130.

171—What is the best way of testing meters on the customer's premises?—20, 86.

172—What degree of accuracy at five per cent of full load is it practically possible to maintain on wattmeters of the commutator type?—11, 26, 35, 49, 63, 112, 123.

173—What is the maintenance cost per kw-hour of the different types of Nernst lamps?—25, 34, 110.

174—What is the ratio of burnouts in a Nernst lamp between the ballasts and glowers of the lamp?—25, 28, 66, 110, 115, 118.

175—What results, as compared with arc lights, has the Nernst lamp given for street lighting?—66, 115, 134.

176—Do Nernst lamps prove troublesome in their operation?—2, 25, 28, 66, 110, 115, 134.

177—As Nernst lamps consume much less current than other lamps in proportion to illumination, how is the customer charged for this service?—2, 110, 115, 134.

178—Are Nernst lamps furnished by the lighting company, or do the customers, in the majority of cases, furnish their own lamps?—2, 25, 110, 115, 134.

179—Has any one put Nernst lamps to a commercial use?—25, 34, 67, 110, 115, 134.

180—Are Nernst lamps as efficient on watts consumed as claimed by manufacturers?—12, 28, 35, 66, 110, 115, 134.

181—What is the average life of Nernst-lamp glowers on good regulation, from practical experience?—2, 12, 25, 110, 115, 134.

182—What globes have you found for interior arc lighting that are more decorative than the plain white or clear glass, and within reason as to cost and weight, while not absorbing more light than an opalescent globe?—35.

183—What are the probable future relations between heat supply and light and power in both residence and business districts?

184—What percentage of loss between the station metered output and the customer's metered current should be considered good results in a station having an annual output of 800,000 kw-hours?—56, 64.

201—Would it not be advisable to establish a standard system of reports for the operation of electric plants? In order to accomplish this, each member should submit a sample of his reports, and the whole should be submitted to a committee to suggest a standard form.—5, 92, 126.

202—Which has been found most satisfactory in small towns—meter or flat rates, or a combination of the two?—5, 16, 21, 38, 47, 52, 56, 64, 65, 74, 89, 120, 122, 126, 133, 145, 147.

203—Which is preferable—to make a high rate per kw-hour and give liberal discounts, say up to 50 per cent, to large consumers, or to make a low rate with a maximum discount of, say, 10 per cent?—21, 35, 47, 48, 52, 64, 65, 74, 96, 120, 122, 145.

204—What is the proper method of charging for exhaust-steam heating?—35, 105, 114.

205—What position is being taken by central stations generally with regard to customers putting on 2-cp and 4-cp lamps? Does it pay to give free renewals?—16, 35, 46, 52, 56, 64, 72, 73, 74, 89, 122, 126, 146.

206—What success are central stations having in pushing motor-driven ice-making and refrigerating plants for saloons, restaurants, markets and residences?—35, 64, 71, 87, 89.

207—Is it for the best interests of small companies to do a wiring business?—11, 12, 16, 35, 46, 47, 52, 65, 72, 73, 74, 89, 120, 147.

208—How far should a station go in the handling of supplies where there are wiring contractors in the town?—5, 11, 56, 65, 72, 73, 89, 150.

209—Should not central stations regulate, to some extent at least, the prices charged by wiring contractors?—21, 73, 74, 89, 120.

210—Is it economical practice to maintain a storekeeper in a plant of, say, 1000-hp capacity, supplying 300 arc lamps?—21, 65, 73, 87, 90.

211—How do you keep account of stock? Will you kindly send forms, if necessary for complete explanation?—14, 35, 39, 90.

212—Should stations dip lamps free of cost for their customers, in addition to furnishing free lamp renewals?—13, 72, 89, 122, 126.

213—Does it pay to support display rooms?—5, 46, 89, 137.

214—Will you give a list of articles desirable for an attractive display for the office of a lighting company, together with scheme for arrangement?—10, 89.

215—How is plant or betterment account taken care of in the large stations? —92.

216—How do you figure depreciation?—5, 35, 65, 92.

217 What is the best method for control and disposal of scrap?—56.

218—Has the Doherty rate been applied to power consumers; if so, what is the usual basis of computation?—31.

219—Is the Doherty rate of special value to plants of small size (225 consumers) in cities of 3000 inhabitants?—31.

220—When meters are used by an electric-light plant, should there be a minimum rate paid irrespective of the meter readings; if so, what should the minimum rate be?—26, 30, 39, 63, 126, 147.

221—Should the minimum rate be the same in a summer resort, where one-half to five-eighths of the lights are used for three or four months in the summer by customers whose winter bills are not more than 10 per cent of the summer bills; if not, what should the minimum rate be in such a town?—26, 128

222—Is it good practice to charge summer customers, or three and four-month customers, the same rate as twelve-month customers; if not, what is the best method of charging for such customers?—35, 56.

223—Will it not be necessary to discriminate in the rates for the different types of illuminants where the operating company owns lamps and furnishes renewals, if the cost of maintenance per kw-hour varies greatly?—35, 56.

224 In changing from an overhead to an underground system, what is the best practice with regard to charging for new underground house connections?—35, 56.

225—What has been the experience of water-power plants with the maximum-demand flat rate, controlled by a Lacey controller, or similar device?—122.

226—What is the relative value of good gas per 1000 feet for illuminating purposes, when used with the best Welsbach burners, as compared with electric current at 15 cents per kw-hour, used in 3.5-watt incandescent lamps; the consumer buying his own mantles, chimneys, etc., but the incandescent lamps being furnished free by the electric-light company?—30.

227—How far should electric-light and power companies go in the matter of statistics?—35, 65.

228—Does the use made of daily load diagrams of station-generated and substation-distributed outputs warrant their cost?—35, 56.

229—What is the best method of meeting gas-arc and Welsbach competition with gas at $1.25 per 1000 feet?—26, 56.

230—Would it not be a good idea for the association to establish a bureau of advertising to suggest forms for local advertising to secure business of lighting, power, etc., and to furnish these from time to time to the members? It would also be a good plan, in the interests of the larger stations, for this bureau to keep in touch with capable electricians and other high-class employees.—35.

231—What methods of advertising and soliciting are found to be most successful in obtaining new business?—35, 39, 40, 52.

232—Outside of cultivating a day load by supplying power, what is being done generally toward encouraging the use of summer current by water-power plants?—122.

233—What is the best method of illustrating the superiority of electric-arc lighting with reference to general illumination, matching colors, etc., in form of circular or card that can be kept prominently before the public? In other words, can a card or circular be printed in several colors, each color labeled, and instructions be printed on the card for viewing same under various lights, noting the difference in appearance under each and in daylight? What colors should be used for best results in comparisons between electric and gas arcs?—117.

234—How can central stations best dispose of electrical or other apparatus that is too small for, or not otherwise suited to, present or future requirements?—39, 52, 61.

235—What is the most equitable method of arriving at the selling price of a small electric-lighting plant which cost $18,000; gross earnings $6000 per year, increasing all the time; operating expenses, taxes and repairs, $3000; net earnings, $3000. Municipality wants to buy for $18,000—cost of plant. Lighting company wants $30,000, at which price plant would be 10 per cent on investment. Which is the equitable price, or should some other price be made, and if so, how would you arrive at same?—56, 83.

236—Is it a good investment, in a small electric-light plant running from dusk to dawn, to install an exhaust-steam-heating system to sell exhaust steam?—56.

237—Would it not be profitable for the members of this association to organize a mutual insurance company?—35, 56, 147.

251—Will you describe a cheap and convenient method of reproducing maps and other drawings where there are no facilities for blue-printing?—35, 50, 73.

252—Why should electric-light carbons take such a high freight rate; or, rather, why should they not take the same rate as other commodities of equal value and risk?—56.

253—What is the best method by which to combat the "friendly feeling" among the three largest builders of electrical machinery?—35, 39, 73.

254—With very few exceptions, lightning will travel to station *against* direction of series current. What is the reason of this?—15, 69.

255—Why not request dealers in the far East of the United States always to send a net price list with advertisements sent to the extreme West of the United States, and thus avoid a season's delay ?—39.

256—What bearing on the electrical industry and its operation has the employment of boys or young men of, say, eighteen, of no skill or experience; grammar-school graduates of limited education, with one or more years' experience in mechanical work of some kind ?—35.

257—What is to be the result of the agitation throughout the country regarding municipalities entering the lighting business ?—65.

CONVENTIONS OF THE ASSOCIATION

First	Chicago, February 25, 26, 1885
Second	New York, August 18, 19, 20, 1885
Third	Baltimore, February 10, 11, 12, 1886
Fourth	Detroit, August 31, September 1, 2, 1886
Fifth	Philadelphia, February 15, 16, 17, 1887
Sixth	Boston, August 9, 10, 11, 1887
Seventh	Pittsburg, February 21, 22, 23, 1888
Eighth	New York, August 29, 30, 31, 1888
Ninth	Chicago, February 19, 20, 21, 1889
Tenth	Niagara Falls, August 6, 7, 8, 1889
Eleventh	Kansas City, February 11, 12, 13, 14, 1890
Twelfth	Cape May, August 19, 20, 21, 1890
Thirteenth	Providence, February 17, 18, 19, 1891
Fourteenth	Montreal, September, 7, 8, 9, 10, 1891
Fifteenth	Buffalo, February 23, 24, 25, 1892
Sixteenth	St. Louis, February 28, March 1, 2, 1893
Seventeenth	Washington, February 27, 28, March 1, 2, 1894
Eighteenth	Cleveland, February 19, 20, 21, 1895
Nineteenth	New York, May 5, 6, 7, 1896
Twentieth	Niagara Falls, June 8, 9, 10, 1897
Twenty-first	Chicago, June 7, 8, 9, 1898
Twenty-second	New York, May 23, 24, 25, 1899
Twenty-third	Chicago, May 22, 23, 24, 1900
Twenty-fourth	Niagara Falls, May 21, 22, 23, 1901
Twenty-fifth	Cincinnati, May 20, 21, 22, 1902
Twenty-sixth	Chicago, May, 26, 27, 28, 1903

PRESIDENTS OF THE ASSOCIATION

James F. Morrison, of Baltimore
Samuel A. Duncan, of Pittsburg
Edwin R. Weeks, of Kansas City
Marsden J. Perry, of Providence
Charles R. Huntley, of Buffalo
James I. Ayer, of St. Louis
Edward A. Armstrong, of Camden
M. Judson Francisco, of Rutland
C. H. Wilmerding, of Chicago
Frederic Nicholls, of Toronto
Samuel Insull, of Chicago
Alden M. Young, of Waterbury
Samuel T. Carnes, of Memphis
James Blake Cahoon, of New York
Henry L. Doherty, of Denver
Louis A. Ferguson, of Chicago

HONORARY MEMBERS

R. E. Crompton, London, England
Marcel Deprez, Paris, France
George D. Forbes, London, England
Prof. I. Fujioka, Tokyo, Japan
Edouard Hospitalier, Paris, France
Dr. E. L. Nichols, Cornell University, Ithaca, New York
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John T. Sprague, Birmingham, England
Joseph W. Swan, Lauriston, Bromley, Kent, England
Prof. Sylvanus B. Thompson, Technical College, Finsbury, London, England
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Charles F. Brush, Cleveland, Ohio
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Prof. Elihu Thomson, Lynn, Massachusetts
Frank J. Sprague, New York City
George S. Bowen, Elgin, Illinois
Prof. Edward Weston, Newark, New Jersey
Sir William Dawson, Montreal, Canada
Frank R. Redpath, Montreal, Canada
Prof. Henry T. Bovey, McGill University, Montreal, Canada
Thomas D. Lockwood, Boston, Massachusetts
Nikola Tesla, New York City
James I. Ayer, Boston, Massachusetts
Cyrus O. Baker, Jr., New York City
Frederic Nicholls, Toronto, Canada

ACTIVE MEMBERS

ALABAMA

Anniston,	Anniston Electric and Gas Company
Birmingham,	Birmingham Railway, Light and Power Company
Demopolis,	Demopolis Electric Light and Power Company
Mobile,	Mobile Light and Railroad Company

ARIZONA

Phœnix,	Phœnix Light and Fuel Company
Prescott,	The Prescott Electric Company
Tucson,	United States Light and Traction Company

ARKANSAS

Eureka Springs,	Citizens' Electric Company
Fort Smith,	Fort Smith Light and Traction Company
Little Rock,	Little Rock Railway and Electric Company
Pine Bluff,	Pine Bluff Light and Water Company

CALIFORNIA

Los Angeles,	Edison Electric Company
	Pacific Light and Power Company
	The Los Angeles Electric Company
Marysville,	Marysville Gas and Electric Company
Ontario,	Ontario Power Company
Sacramento,	Sacramento Electric, Gas and Railway Company
San Francisco,	Mutual Electric Company
	San Francisco Gas and Electric Company
San Leandro,	Suburban Electric Light Company
Stockton,	Stockton Gas and Electric Company

COLORADO

Aspen,	The Roaring Fork Electric Light and Power Company
Cañon City,	The Colorado Electric Power Company
Colorado Springs,	The Colorado Springs Electric Company
Denver,	Denver Gas and Electric Company
	Mountain Electric Company
	United States Light and Traction Company
Durango,	The Durango Light and Power Company
Fort Collins,	The Larimer Light and Power Company
Georgetown,	The United Light and Power Company

COLORADO—*Continued*

GOLDEN,	The Golden Illuminating Company
IDAHO SPRINGS,	The Cascade Electric Company
	The Consolidated Gem Mines Company, Electrical Department
LAMAR,	The Lamar Electric Company
LAS ANIMAS,	Las Animas Electric Company
LEADVILLE,	Leadville Gas and Electric Company
MANITOU,	The Manitou Electric Company
OURAY,	The Ouray Electric Light and Power Company
PUEBLO,	Pueblo and Suburban Traction and Lighting Company
TELLURIDE,	The Telluride Electric Light and Power Company
	The Telluride Power Company
VICTOR,	The Pueblo and Suburban Traction and Lighting Company

CONNECTICUT

BRANFORD,	Branford Lighting and Water Company
BRIDGEPORT,	Connecticut Railway and Lighting Company
DANBURY,	Danbury and Bethel Gas and Electric Light Company
DANIELSON,	People's Light and Power Company
DERBY,	Derby Gas Company
HARTFORD,	Hartford Electric Light Company
LITCHFIELD,	The Litchfield Electric Light and Power Company
MERIDEN,	Meriden Electric Light Company
MYSTIC,	The Mystic Electric and Gas Light Company
NEW LONDON,	The New London Gas and Electric Company
NORWICH,	Norwich Gas and Electric Company
ROCKVILLE,	The Rockville Gas and Electric Company
STAMFORD,	Stamford Gas and Electric Company
SUFFIELD,	Village Water Company
THOMPSONVILLE,	Enfield Electric Light and Power Company
UNIONVILLE,	The Union Electric Light and Power Company
WESTPORT,	Westport Water and Electric Light Company

DELAWARE

WILMINGTON,	The Wilmington City Electric Company

DISTRICT OF COLUMBIA

WASHINGTON,	Potomac Electric Power Company

FLORIDA

KEY WEST,	Key West Electric Company
TAMPA,	Tampa Electric Company

GEORGIA

AMERICUS,	Americus Illuminating and Power Company

GEORGIA—*Continued*

Athens,	Athens Electric Railway Company
Atlanta,	Georgia Railway and Electric Company
Augusta,	Augusta Railway and Electric Company
Columbus,	The Columbus Railroad Company
Savannah,	Savannah Electric Company
Thomasville,	Thomasville Electric Light and Gas Company

HAWAII

Honolulu,	Hawaiian Electric Company, Limited

IDAHO

Boise,	Capital Electric Light, Motor and Gas Company
Lewiston,	Lewiston Water and Power Company
Pocatello,	American Falls, Power, Light and Water Company

ILLINOIS

Abingdon,	Abingdon Electric Company
Alton,	Alton Light and Traction Company
Bloomington,	Bloomington and Normal Railway, Electric and Heating Company
Canton,	People's Gas and Electric Light Company
Centralia,	Centralia Gas and Electric Company
Chester,	The Chester Light, Water and Ice Company
Chicago,	Chicago Edison Company
	Chicago Sectional Electric Underground Company
	Commonwealth Electric Company
Clinton,	Clinion Gas Company
DeKalb,	DeKalb-Sycamore Electric Company
Dixon,	Dixon Power and Lighting Company
Edwardsville,	Edwardsville Electric Light and Power Company
Evanston,	North Shore Electric Company
Hillsboro,	Hillsboro Electric Light and Power Company
Jacksonville,	Jacksonville Gas Light and Coke Company
Joilet,	Economy Light and Power Company
Moline,	People's Power Company
Nokomis,	Nokomis Electric Light and Power Company
Peoria,	Peoria Gas and Electric Company
Pontiac,	Pontiac Light and Water Company
Quincy,	The Independent Light and Power Company
Rockford,	Rockford Edison Company
Springfield,	Springfield Electric Light and Power Company
	The Capital Electric Company
Streator,	Streator Gas and Light Company
Taylorville,	Taylorville Electric Company
Warsaw,	Warsaw Electric Light Plant
Watseka,	Watseka Electric and Heat Company

INDIANA

Alexandria,	Alexandria Electric Light and Power Company
Elkhart,	Elkhart Electric Company
Elwood,	Elwood Electric Light Company
Evansville,	Evansville Gas and Electric Light Company
Fort Wayne,	Jenney Electric Light and Power Company
Goshen,	The Hawks Electric Company
Kokomo,	Kokomo, Marion and Western Traction Company
Madison,	Madison Lighting Company
New Albany,	United Gas and Electric Company
South Bend,	South Bend Electric Company
Terre Haute,	Terre Haute Electric Company
Wabash,	The Wabash Electric Light Company

IOWA

Cedar Rapids,	Cedar Rapids Electric Light and Power Company
Davenport,	People's Light Company
Decorah,	The Decorah Electric Light Company
Des Moines,	Des Moines Edison Light Company
Dubuque,	Union Electric Company
Iowa City,	Iowa City Electric Light Company
Mason City,	Brice Gas and Electric Company
Muscatine,	Citizens' Railway and Light Company
Ottumwa,	Ottumwa Traction and Light Company
Red Oak,	Red Oak Electric Company
Sioux City,	Sioux City Gas and Electric Company

KANSAS

Clay Center,	F. L. Williamson and Company
Columbus,	The Columbus Electric Company
Topeka,	Edison Electric Illuminating Company of Topeka, Kansas

KENTUCKY

Covington,	The Union Light, Heat and Power Company
Lexington,	Lexington Railway Company
Louisville,	Louisville Lighting Company
Paducah,	The Paducah City Railway Company

LOUISIANA

Lake Charles,	The Lake Charles Ice, Light and Water Works Company
New Orleans,	New Orleans and Carrollton Railway, Light and Power Company
Shreveport,	Shreveport Gas, Electric Light and Power Company

MAINE

BANGOR,	Public Works Company
BRUNSWICK,	The Brunswick Electric Light and Power Company
OAKLAND,	Oakland Electric Company
PORTLAND,	Consolidated Electric Light Company of Maine
	Portland Lighting and Power Company
SKOWHEGAN,	Skowhegan Electric Light Company
WATERVILLE,	Waterville and Fairfield Railway and Light Company

MARYLAND

BALTIMORE,	The United Electric Light and Power Company
BEL AIR,	The Bel Air Electric Company
CRISFIELD,	Crisfield Ice Manufacturing Company
FREDERICK,	Frederick Electric Light and Power Company
HAVRE DE GRACE,	The Havre de Grace Electric Company

MASSACHUSETTS

AMHERST,	Amherst Gas Company
ATTLEBORO,	Attleboro Steam and Electric Company
BEVERLY,	Beverly Gas and Electric Company
BOSTON,	Edison Electric Illuminating Company of Boston
BROCKTON,	Edison Electric Illuminating Company of Brockton
BROOKLINE,	Brookline Gas Light Company
CAMBRIDGE,	Cambridge Electric Light Company
CHELSEA,	Chelsea Gas Light Company
CLINTON,	Clinton Gas Light Company
COHASSET,	The Cohasset Electric Company
FALL RIVER,	Fall River Electric Light Company
FITCHBURG,	Fitchburg Gas and Electric Light Company
GARDNER,	Gardner Electric Light Company
HYDE PARK,	Hyde Park Electric Light Company
LAWRENCE,	Lawrence Gas Company
LEE,	Lee Electric Company
LEXINGTON,	Lexington Gas and Electric Company
LOWELL,	The Lowell Electric Light Corporation
LYNN,	Lynn Gas and Electric Company
MALDEN,	Malden Electric Company
MARLBORO,	Marlborough Electric Company
NEW BEDFORD,	New Bedford Gas and Edison Light Company
NEWTON,	Newton and Watertown Gas Light Company
NORTH ADAMS,	North Adams Gas Light Company
PITTSFIELD,	Pittsfield Electric Company
PLYMOUTH,	Plymouth Electric Light Company
REVERE,	Suburban Gas and Electric Company
SOUTHBRIDGE,	Andrew F. Hall
SPRINGFIELD,	United Electric Light Company
WEBSTER,	Webster Electric Company
WESTBORO,	Westboro Gas and Electric Company

MASSACHUSETTS—*Continued*

WEST SOMERVILLE,	Somerville Electric Light Company
WHITMAN,	Whitman Light and Power Company
WINCHENDON,	Winchendon Electric Light and Power Company
WOBURN,	Woburn Light, Heat and Power Company
WORCESTER,	Worcester Electric Light Company

MICHIGAN

ADRIAN,	The Citizens' Light and Power Company
ALPENA,	Alpena Electric Light Company
ANN ARBOR,	Washtenaw Light and Power Company
BIG RAPIDS,	W. E. Donley Electric Light and Power Company
BROOKLYN,	Brooklyn Electric Light Company
CORUNNA,	Shiawassee Light and Power Company
DETROIT,	Peninsular Electric Light Company
EATON RAPIDS,	Citizens' Electric Company
HOUGHTON,	Houghton County Electric Light Company
IONIA,	Ionia Electric Company
JACKSON,	Jackson Light and Power Company
KALAMAZOO,	Kalamazoo Valley Electric Company
MANCELONA,	Mancelona Electric Light and Power Company
PLAINWELL,	Arnold and Brownell Electric Company
PORT HURON,	Port Huron Light and Power Company
SAGINAW,	Bartlett Illuminating Company
ST. JOSEPH,	Benton Harbor and St. Joseph Electric Railway and Light Company
SAULT STE. MARIE,	Trans-St. Mary Traction Company

MINNESOTA

ALBERT LEA,	Albert Lea Light and Power Company
CROOKSTON,	Crookston Water Works, Power and Light Company
DULUTH,	Duluth General Electric Company
FARIBAULT,	The Faribault Gas and Electric Company
LITTLE FALLS,	The Little Falls Water Power Company of Minnesota
MINNEAPOLIS,	The Minneapolis General Electric Company
PIPESTONE,	Pipestone Electric Light, Heat and Power Company
RED WING,	Red Wing Gas and Electric Company
ST. CLOUD,	Light, Heat, Transit and Public Service Company
ST. PAUL,	Edison Electric Light and Power Company of St. Paul
WINONA,	Winona Railway and Light Company.

MISSISSIPPI

ABERDEEN,	J. F. Enderlin Electric Light Company
COLUMBUS,	Columbus Light and Power Company
MERIDIAN,	Meridian Light and Railway Company
VICKSBURG,	Vicksburg Railway and Light Company

MISSOURI

De Soto,	Consumers' Electric Light and Power Company
Joplin,	Southwest Missouri Light Company
Kansas City,	The Kansas City Electric Light Company
Monett,	Monett Electric Light, Power and Ice Company
St. Louis,	The Laclede Gas Light Company
	The Laclede Power Company of St. Louis
	Union Electric Light and Power Company
Springfield,	Springfield Gas and Electric Company
Washington,	Tibbe Electric Company

MONTANA

Anaconda,	The Anaconda Copper Mining Company, Electric Light and Railway Department
Big Timber,	Bigtimber Electric Light and Power Company
Billings,	Billings Water Power Company
Butte,	Butte Electric and Power Company
Great Falls,	Boston and Great Falls Electric Light and Power Company
Helena,	Helena Light and Traction Company
Kalispell,	Big Fork Electric Power and Light Company
Missoula,	Missoula Light and Power Company

NEBRASKA

Beatrice,	Beatrice Electric Company
Kearney,	The Northwestern Electric, Heat and Power Company
Lincoln,	Lincoln Gas and Electric Light Company
Omaha.	Omaha Electric Light and Power Company

NEW HAMPSHIRE

Concord,	Concord Electric Company
Dover,	United Gas and Electric Company
Franklin Falls,	The Franklin Light and Power Company
Keene,	Keene Gas and Electric Company
Manchester,	Manchester Traction, Light and Power Company
Nashua,	Nashua Light, Heat and Power Company
Newport,	Newport Electric Light Company
Portsmouth,	Rockingham County Light and Power Company

NEW JERSEY

Asbury Park,	Atlantic Coast Electric Light Company
Atlantic City,	The Atlantic Electric Light and Power Company
Dover,	Dover Electric Light Company
Egg Harbor,	Atlantic County Electric Company
Elizabeth,	United Electric Company of New Jersey
Hackensack,	The Gas and Electric Company of Bergen County
Hoboken,	United Electric Company of New Jersey

NEW JERSEY—*Continued*

Jersey City,	United Electric Company of New Jersey
Lambertville,	Hunterdon Electric Company
Long Branch,	Consolidated Gas Company of New Jersey
Morristown,	United Electric Company of New Jersey
Newark,	Public Service Corporation of New Jersey, Electric Department
Orange,	United Electric Company of New Jersey
Paterson,	Public Service Corporation of New Jersey
Plainfield,	Plainfield Gas and Electric Light Company
Trenton,	Public Service Corporation of New Jersey
Washington,	Washington Electric Light Company

NEW MEXICO

Santa Fé,	Santa Fé Water and Light Company

NEW YORK

Albion,	Albion Power Company
Alexandria Bay,	St. Lawrence International Electric Railroad and Land Company
Auburn,	Auburn Light, Heat and Power Company
Batavia,	Consolidated Gas and Electric Company
Binghamton,	Binghamton Light, Heat and Power Company
Brooklyn,	Edison Electric Illuminating Company of Brooklyn
Buffalo,	Buffalo General Electric Company
Cazenovia,	The Union Electric Company
Cooperstown,	The Clinton Mills Power Company
Dundee,	Dundee Electric Light Plant
Elmira,	Elmira Water, Light and Railroad Company
Far Rockaway,	Queens Borough Gas and Electric Company
Fishkill-on-Hudson	Citizens' Railroad, Light and Power Company
Fulton,	Fulton Light, Heat and Power Company
Glens Falls,	Hudson River Water Power Company
Gloversville,	Fulton County Gas and Electric Company
Greenwich,	Consolidated Electric Company
Hoosick Falls,	Hoosick Falls Electric Company
Ithaca,	Ithaca Electric Light and Power Company
Jamestown,	Jamestown Lighting and Power Company
Keeseville,	Keeseville Electric Company
Kingston,	Kingston Gas and Electric Company
Liberty,	Liberty Light and Power Company
Long Island City,	New York and Queens Electric Light and Power Company
Lyons,	Wayne County Electric Company
Mount Vernon,	Westchester Lighting Company
Newburgh,	Newburgh Light, Heat and Power Company
New York City,	New York Edison Company United Electric Light and Power Company

NEW YORK—*Continued*

Niagara Falls,	Buffalo and Niagara Falls Electric Light and Power Company
	The Niagara Falls Hydraulic Power and Manufacturing Company
	The Niagara Falls Power Company
Norwich,	Norwich Gas and Electric Company
Nyack,	Rockland Light and Power Company
Oneida,	Madison County Gas and Electric Company
Oneonta,	Oneonta Light and Power Company
Ovid,	Ovid Electric Company
Peekskill,	Peekskill Lighting and Railroad Company
Port Jervis,	Port Jervis Light, Power, Gas and Railroad Company
Potsdam,	The Potsdam Electric Light and Power Company
Poughkeepsie,	Poughkeepsie Light, Heat and Power Company
Richfield Springs,	Richfield Springs Electric Light and Power Company
Rochester,	Rochester Gas and Electric Company
Roslyn,	Nassau Light and Power Company
Saranac Lake,	Saranac Lake Light, Heat and Power Company
Schenectady,	Schenectady Railway Company
Southampton,	The Southampton Electric Light Company
Syracuse,	Syracuse Lighting Company
Tonawanda,	Tonawanda Power Company
Tuxedo Park,	Tuxedo Electric Light Company
Utica,	Utica Gas and Electric Company
Watertown,	Watertown Electric Light Company

NORTH CAROLINA

Asheville,	Asheville Electric Company
Durham,	Durham Traction Company
Henderson,	Henderson Lighting and Power Company
Raleigh,	The Raleigh Electric Company
Winston-Salem,	The Fries Manufacturing and Power Company

NORTH DAKOTA

Grand Forks,	Grand Forks Gas and Electric Company

OHIO

Akron,	The Northern Ohio Traction and Light Company
Alliance,	Alliance Gas and Electric Company
Canton,	Canton Light, Heat and Power Company
Cincinnati,	The Cincinnati Gas and Electric Company
Cleveland,	The Cleveland Electric Illuminating Company
Columbus,	The Columbus Railway and Light Company
Defiance,	People's Gas and Electric Company
Elyria,	The Citizens' Gas and Electric Company
Lancaster,	The Lancaster Electric Light Company
Leipsic,	Leipsic Electric Light, Heat and Power Company

OHIO—*Continued*

Lima,	The Lima Electric Railway and Light Company
Lisbon,	The New Lisbon Gas Company
Portsmouth,	Portsmouth Street Railroad and Light Company
Salem,	The Salem Electric Light and Power Company
Springfield,	The Springfield Light and Power Company
Steubenville,	The Steubenville Traction and Light Company
Toledo,	The Toledo Railways and Light Company
Warren,	The Warren Electric Light and Power Company
Youngstown,	Youngstown Consolidated Gas and Electric Company
Zanesville,	The Zanesville Railway, Light and Power Company

OKLAHOMA

Guthrie,	The New Electric and Gas Light Company
Shawnee,	The Shawnee Light and Power Company

ONTARIO

London,	The London Electric Company, Limited
Ottawa,	The Ottawa Electric Company

OREGON

Ashland,	Ashland Electric Power and Light Company
Marshfield,	Marshfield Lighting Company
Portland,	Portland General Electric Company
Salem,	Citizens' Light and Traction Company
Sumpter,	The Sumpter Light and Water Company of Sumpter, Oregon

PENNSYLVANIA

Altoona,	The Edison Electric Illuminating Company of Altoona
Bethlehem,	The Bethlehem Electric Light Company
Bradford,	Bradford Electric Light Company
Bristol,	The Bristol Electric Light and Power Company
Carbondale,	Lackawanna Valley Electric Light and Power Supply Company
Carlisle,	The Carlisle Gas and Water Company
Connellsville,	The Electric Company
Danville,	Standard Electric Light Company
Doylestown,	Doylestown Electric Company
Easton,	Easton Power Company
Erie,	The Erie Company
Franklin,	Franklin Electric Company
Lewistown,	Lewistown Electric Light Company
Manheim,	Lancaster Valley Electric Light Company
Morton,	Faraday Heat, Power and Light Company
New Castle,	New Castle Electric Company
Oil City,	Citizens' Light and Power Company

PENNSYLVANIA—*Continued*

PHILADELPHIA,	The American Railways Company
	The Brush Electric Light Company of Philadelphia
	The Electric Company of America
PHILIPSBURG,	The Philipsburg Electric Light, Gas, Power and Heating Company
PHŒNIXVILLE,	Phœnix Gas and Electric Company
PITTSTON,	Citizens' Electric Illuminating Company
READING,	Metropolitan Electric Company
SCRANTON,	Scranton Illuminating, Heat and Power Company
TOWANDA,	Towanda Electric Illuminating Company
WARREN,	Warren Electrical Light Company
WASHINGTON,	The Washington Electric Light and Power Company
WAYNESBORO,	Waynesboro Electric Light and Power Company
WAYNESBURG,	Waynesburg Electric Light and Power Company
WEST CHESTER,	The Edison Electric Illuminating Company
WILLIAMSPORT,	Lycoming Electric Company
YORK,	Edison Electric Light Company

QUEBEC

AYLMER,	Hull Electric Company
MONTREAL,	Lachine Rapids Hydraulic and Power Company
	Montreal Light, Heat and Power Company
QUEBEC,	Quebec-Jacques Cartier Electric Company
	The Canadian Electric Light Company
	The Quebec Railway, Light and Power Company
SHERBROOKE,	The Sherbrooke Power, Light and Heat Company

RHODE ISLAND

NEWPORT,	Newport and Fall River Street Railway and Lighting Company
PAWTUCKET,	Pawtucket Electric Company
PROVIDENCE,	Narragansett Electric Lighting Company
WOONSOCKET,	Woonsocket Electric Machine and Power Company

SOUTH CAROLINA

GEORGETOWN,	Georgetown Electric Company

SOUTH DAKOTA

LEAD,	Belt Light and Power Company

TENNESSEE

CHATTANOOGA,	Chattanooga Light and Power Company
COLUMBIA,	Columbia Water and Light Company
KNOXVILLE,	The Knoxville Electric Light and Power Company
MEMPHIS,	Memphis Consolidated Gas and Electric Company
NASHVILLE,	Nashville Railway and Light Company

TEXAS

Brenham,	Brenham Compress, Oil and Manufacturing Company
Cleburne,	The Cleburne Light and Power Company
Corsicana,	Corsicana Gas and Electric Company
Dallas,	Dallas Electric Light and Power Company
	Dallas Ice Factory, Light and Power Company
El Paso,	International Light and Power Company
Gainesville,	Merchants' Electric Light and Power Company
Marshall,	Arkansas and Texas Consolidated Ice and Coal Company
Paris,	Paris Light and Power Company
San Antonio,	San Antonio Gas and Electric Company
Taylor,	Taylor Electric Light Company
Waxahachie,	Waxahachie Electric Light Company

UTAH

Salt Lake City,	Utah Light and Power Company

VERMONT

Bellows Falls,	The Fall Mountain Electric Light and Power Company
Bennington,	Bennington Water Power and Light Company
Brandon,	Neshobe Electric Company
Fair Haven,	Fair Haven Electric Company
Middlebury,	Middlebury Electric Company
Montpelier,	Consolidated Lighting Company
Rutland,	Rutland City Electric Company
St. Johnsbury,	St. Johnsbury Electric Company
Vergennes,	The Vergennes Electric Company

VIRGINIA

Lynchburg,	Lynchburg Traction and Light Company
Richmond,	Virginia Passenger and Power Company
Roanoke,	Roanoke Railway and Electric Company

WASHINGTON

Dayton,	Dayton Electric Light and Power Company
Everett,	Everett Railway and Electric Company
Hoquiam,	Gray's Harbor Electric Company
Seattle,	Snoqualmie Falls Power Company
	The Seattle Electric Company
Walla Walla,	Walla Walla Gas and Electric Company

WEST VIRGINIA

Charleston,	Kanawaha Water and Light Company
Davis,	Davis Electric Light Company
Parkersburg,	Parkersburg, Marietta and Inter-Urban Railway Company

WEST VIRGINIA—*Continued*

SISTERSVILLE,	Sistersville Electric Light and Power Company
WHEELING,	The Wheeling Electrical Company

WISCONSIN

ANTIGO,	Antigo Light, Heat and Power Company
DELAVAN,	Delavan Light and Fuel Company
EAU CLAIRE,	Eau Claire Light and Power Company
FOND-DU-LAC,	Eastern Wisconsin Railway and Light Company
JANESVILLE,	Janesville Electric Company
KENOSHA,	Kenosha Gas and Electric Company
LA CROSSE,	La Crosse Gas and Electric Light Company
MADISON,	Madison Gas and Electric Company
MARSHFIELD,	Marshfield Water, Electric Light and Power Company
MENOMONIE,	Menomonie Electric Light and Power Company
MERRILL,	Merrill Railway and Lighting Company
OCONTO,	W. A. Holt
PORT WASHINGTON,	The Wisconsin Chair Company
RHINELANDER,	Rhinelander Lighting Company
WAUKESHA,	Waukesha Gas and Electric Company
WAUPACA,	Waupaca Electric Light and Railway Company
WAUSAU,	Wausau Electric Company

WYOMING

CHEYENNE,	Cheyenne Light, Fuel and Power Company

ASSOCIATE MEMBERS

AMPERE, N. J.,	Crocker-Wheeler Company
AUBURN, N. Y.,	McIntosh, Seymour and Company
BALTIMORE, MD.,	Electrical Material Company
BOSTON, MASS.,	Albert and J. M. Anderson Manufacturing Company
	American Circular Loom Company
	Frank Ridlon Company
	Pettingell-Andrews Company
BRIDGEPORT, CONN.,	Bryant Electric Company
BUFFALO, N. Y.,	Charles F. Johnson
CHICAGO, ILL.,	Chicago Fuse Wire and Manufacturing Company
	Chicago Insulated Wire Company
	Electric Appliance Company
	Gregory Electric Company
	The Sterling Company
	Western Electric Company
	Western Electrician
CINCINNATI, OHIO,	Bullock Electric Manufacturing Company
	Triumph Electric Company
CLEVELAND, OHIO,	Adams-Bagnall Electric Company
	Buckeye Electric Company
	National Carbon Company
	The United States Carbon Company
COVINGTON, KY.,	Hemingray Glass Company
DAYTON, OHIO,	National Cash Register Company
FORT WAYNE, IND.,	Fort Wayne Electric Works
FOSTORIA, OHIO,	Crouse-Tremaine Carbon Company
GREAT BARRINGTON, MASS.,	Stanley Instrument Company
LOCKPORT, N. Y.,	American District Steam Company
MATTEAWAN, N. Y.,	The Green Fuel Economizer Company
MILWAUKEE, WIS.,	National Electric Company
NEWARK, N. J.,	Baker and Company
	The G. McIntire Company
	Weston Electrical Instrument Company
NEWBURYPORT, MASS.,	Chase-Shawmut Company
NEW YORK CITY,	A. G. Schoonmaker Company
	Alberger Condenser Company
	American Vitrified Conduit Company
	Bryan-Marsh Company
	Elblight Electric Company of America
	Electrical Review Publishing Company

NEW YORK CITY,	*Electricity* Newspaper Company
	Franklin H. Kalbfleisch Company
	General Electric Company
	General Incandescent Arc Light Company
	Gould Storage Battery Company
	H. B. Camp Company
	Hugo Reisinger
	H. W. Johns-Manville Company
	India Rubber and Gutta Percha Insulating Company
	J. A. and W. Bird Company
	J. G. White Company
	John A. Roebling's Sons Company
	Lamp Testing Bureau
	Manhattan Electrical Supply Company
	Manhattan General Construction Company
	McGraw Publishing Company
	National Conduit and Cable Company
	New York Insulated Wire Company
	Osburn Flexible Conduit Company
	Rossiter, MacGovern and Company
	Sprague Electric Company
	Standard Vitrified Conduit Company
	The *Central Station*
	The Dale Company
	The Okonite Company, Limited
	The Phœnix Glass Company
	The Standard Paint Company
PHILADELPHIA, PA.,	Alfred F. Moore
	Electric Storage Battery Company
	R. D. Wood and Company
PITTSBURG, PA.,	Doubleday-Hill Electric Company
	Nernst Lamp Company
	Standard Underground Cable Company
	Westinghouse Electric and Manufacturing Company
PITTSFIELD, MASS.,	Stanley Electric Manufacturing Company
PROVIDENCE, R. I.,	American Electrical Works
	New England Butt Company
ST. CATHERINES, ONTARIO,	The Packard Electric Company, Limited
ST. LOUIS, MO.,	Columbia Incandescent Lamp Company
SCHENECTADY, N. Y.,	William T. Taylor
SPRINGFIELD, MASS.,	Munder Electrical Works
SYRACUSE, N. Y.,	Crouse-Hinds Electric Company
	Pass and Seymour
WARREN, OHIO,	New York and Ohio Company

OFFICERS AND EXECUTIVE COMMITTEE

Officers

Charles L. Edgar	President
S. B. Livermore	First Vice-President
J. W. Lieb, Jr.	Second Vice-President
Ernest H. Davis	Secretary and Treasurer
H. Billings	Asst. Secretary and Treasurer
C. O. Baker, Jr.	Master of Transportation

Executive Committee

Elected at the Twenty-third to serve until the close of the Twenty-sixth Convention

Charles B. Hunt
Henry L. Doherty
Ernest H. Davis

Elected at the Twenty-fourth to serve until the close of the Twenty-sixth Convention

Dudley Farrand (in place of Charles B. Hunt, promoted)
E. L. Bemiss (in place of Henry L. Doherty, promoted)

Elected at the Twenty-fourth to serve until the close of the Twenty-seventh Convention

Charles L. Edgar
C. C. Howell
D. P. Robinson

Elected at the Twenty-fifth to serve until the close of the Twenty-sixth Convention

Arthur Williams (in place of Ernest H. Davis, promoted)

Elected at the Twenty-fifth to serve until the close of the Twenty-seventh Convention

J. H. Perkins (in place of Charles L. Edgar, promoted)
C. F. Hewitt (in place of C. C. Howell, deceased)

Elected at the Twenty-fifth to serve until the close of the Twenty-eighth Convention

A. C. Dunham
P. G. Gossler
H. T. Hartman

Elected at the Twenty-sixth to serve until the close of the Twenty-ninth Convention

Louis A. Ferguson
Harry Bottomley
Alex Dow

COMMITTEES

TO REPORT TO THE TWENTY-SIXTH CONVENTION

Committee on Finance

H. H. Fairbanks, Chairman

W. S. Barstow

Edward F. Peck

Committee on Standard Rules for Electrical Construction and Operation

William Brophy, Chairman

James I. Ayer

Charles L. Edgar

Committee on Standard Candle-Power of Incandescent Lamps

Dr. Louis Bell, Chairman

James I. Ayer

Calvin W. Rice

Committee on Amendments to Freight Classification on Electrical Apparatus and Goods

James I. Ayer, Chairman

W. C. Bryant

Geo. W. Davenport

Committee on Legislative Policy

Samuel Insull, Chairman

H. M. Atkinson

Samuel Scovil

Ernest H. Davis

Charles R. Huntley

Committee on Photometric Values of Arc Lamps

Henry L. Doherty, Chairman

Professor W. Elwell Goldsborough

Professor Charles P. Matthews

Committee on Analysis of Flue Gases

Henry L. Doherty, Chairman

W. L. Abbott

Dugald Jackson

Committee on Uniform Accounting

G. E. Tripp, Chairman

W. F. Ham

W. A. Anthony

Committee on Relations Between Manufacturers and Central Station Companies

Charles L. Edgar, Chairman

Henry L. Doherty

A. C. Dunham

Reporter on District Heating	John W. Glidden
Reporter on Office Methods and Accounting	Walter M. Anthony
Reporter on Lost and Unaccounted-for Current	L. G. Van Ness
Reporter on Decorative and Sign Lighting	Arthur Williams
Editor of Progress	T. Commerford Martin
Editor Question Box	H. T. Hartman

COMMITTEES

TO REPORT TO THE TWENTY-SEVENTH CONVENTION

Committee on Finance
H. H. Fairbanks, Chairman
W. S. Barstow
E. F. Peck

Committee on Standard Rules for Electrical Construction and Operation
William Brophy, Chairman
James I. Ayer
Louis A. Ferguson

Committee on Standard Candle-Power of Incandescent Lamps
Dr. Louis Bell, Chairman
James I. Ayer
Calvin W. Rice.

Committee on Legislative Policy
Samuel Insull, Chairman
H. M. Atkinson
Samuel Scovil
Ernest H. Davis
Charles R. Huntley

Committee on Photometric Values of Arc Lamps
Henry L. Doherty, Chairman
W. E. Goldsborough
Charles P. Matthews

Committee on Analysis of Flue Gases
Henry L. Doherty, Chairman
W. L. Abbott
Professor Dugald Jackson

Committee on Uniform Accounting
Guy L. Tripp, Chairman
W. F. Ham
W. A. Anthony

Committee on Relations Between Manufacturers and Central Station Companies
Henry L. Doherty, Chairman
A. C. Dunham
Louis A. Ferguson

Committee on Relations with Kindred Organizations
James I. Ayer, Chairman
J. W. Lieb, Jr.
W. E. Goldsborough

Committee on Purchased Electric Power in Factories
William H. Atkins, Chairman
S. Morgan Bushnell
George W. Brine

Committee for Investigation of Steam Turbines
W. C. L. Eglin, Chairman
Frederic Sargent
A. C. Dunham

Committee on District Heating
E. F. McCabe, Chairman
C. R. Maunsell
D. F. McGee

Reporter on Lost and Unaccounted-for Current	L. G. Van Ness
Reporter on Advertising Methods	La Rue Vredenburgh
Reporter on Decorative and Sign Lighting	Arthur Williams
Editor of Progress	T. Commerford Martin
Editor Wrinkle Department	Charles H. Williams
Editor Question Box	H. T. Hartman

ORDER OF BUSINESS

TUESDAY, May 26th, 1903.

FIRST SESSION, 10.15 A. M.

1. Resolutions of Welcome by City Council of Chicago
2. Address of President Ferguson
3. Announcements
4. Report—Editor of Progress. T. COMMERFORD MARTIN
5. Report—Office Methods and Accounting. WALTER M. ANTHONY

SECOND SESSION, 2.1Q P. M.

1. Paper—"Advantages to Be Derived from Consolidation of Electrical Interests." By SIDNEY HOSMER
2. Paper—"Boiler and Furnace Efficiencies." By A. BEMENT
3. Paper—"Standard Transformer Voltages." By JOHN S. PECK
4. Paper—"The Application of Four-Ampere Series Arc Lamps for City Lighting." By J. HENRY HALLBERG
5. Paper—"Notes on the Inclosed Electric Arc." By PROFESSOR ELIHU THOMSON

MINUTES

OPENING OF THE CONVENTION

The twenty-sixth convention of the National Electric Light Association was held at the Auditorium Hotel, Chicago, Illinois.

The meeting was called to order by President Ferguson at a quarter after ten o'clock, Tuesday morning, May 26, 1903.

The president announced that it had been expected that Honorable Carter H. Harrison, mayor of Chicago, would welcome the delegates, but, owing to business engagements, he was unable to do so. In place of the address of welcome by the mayor, Mr. Edward B. Ellicott, the city electrician, forwarded the following resolution, which had been passed by the City Council at its meeting on Monday, May 25:

"WHEREAS, The National Electric Light Association will hold its twenty-sixth meeting at the Auditorium Hotel in Chicago, beginning Tuesday, May 26, 1903; and

"WHEREAS, Those attending will represent the electric light interests of this country; be it hereby

"*Resolved*, That the members of this Council wish the delegates a successful convention, and authorize his Honor, the Mayor, to extend to them during their visit the freedom of the city of Chicago."

On motion of Mr. Insull, it was voted that a suitable acknowledgment of the resolution be sent to the mayor of the city.

ADDRESS OF PRESIDENT FERGUSON

The year just closing with this convention has been an unusually active one for the officers of your association, as there have been many important matters presented requiring their attention.

Through persistent canvassing the active membership of the association has been increased in one year more than 150 per cent, until now we number in our active and associate membership list 532 members, 452 of whom are active and 80 associates, besides 26 honorary members. The association has become in one year even more national in its character, and its importance and value are becoming more generally recognized.

It has been customary in the past for the president, in opening the convention, to review the development of the art during the year, but we shall this year depart from the usual custom, following the suggestion of our president of last year.

The president of this association should not be burdened by detail, and the office should be that of chief executive, whose duties consist in enlarging the scope and value of the association's work and conserving the interests of its members by directing the forces at his command, rather than that of historian, and the work of review should be done by one whose daily thought and activity are along the lines of watching the development of the art. Following this idea, your president appointed a progress editor, who has covered, in a very exhaustive and elaborate report, the development of electricity in its applications to light and power.

In addition to the standing committees already in existence at the last convention, there have been appointed during the year reporters on five special subjects, all of great importance to the members of the association. These reporters have been actively engaged gathering information and suggestions from all the members, which they have assorted, sifted and compiled, and from which they have drawn certain conclusions which will be submitted to you as recommendations in the form of carefully prepared reports. In most cases these reporters have met with ready and courteous assistance from the members, and I am sure that when their excellent reports are read all those who have assisted in any way will feel amply repaid, for they will then appreciate the immense amount of time and effort that has been expended by these gentlemen who have been so painstaking and unselfish in their work for the association's good. The reports of these special committees are not merely perfunctory reports, but represent months of special and continuous thought, and will prove, I trust, as valuable and interesting as the papers that have been prepared especially for this convention.

The Question Box introduced at the last convention will be treated in a somewhat different manner. It was considered expedient this year to make a special department of this subject, and an editor was appointed to handle it. It has grown to such proportions that your president has deemed it advisable to have the questions and answers printed completely for distribution at this convention, and instead of going through the laborious operation of reading the questions and answers aloud, we have decided to present the Question Box to you in its completed form, and, if found desirable, discuss it at one session of the meeting.

The committee on standard rules for electrical construction and operation has been called upon this year for unusually active work in connection with the National Electrical Code. Certain changes in the rules for overhead construction had been proposed by a committee of the National Underwriters' Electrical Association, and were under consideration by a committee representing the American Institute of Electrical Engineers. Feeling that some of the proposed changes in the rules were impracticable, objectionable and unfair to the member companies of this association, your president communicated with the president of the American Institute of Electrical Engineers, and urged postponement of favorable action on these changes until they might be considered by the National Electric Light Association. The request was granted, and your committee on standard rules for electrical construction and operation was invited to attend the future joint meetings of the committees of the National Underwriters' Electrical Association and of the American Institute of Electrical Engineers.

Two meetings were held in Boston, one in February and one in March, at both of which your committee and your president were in attendance and took an active part. Your committee took the position that no changes could be made in these rules without a meeting of the conference, consisting of representatives of all associations interested in the subject, as follows: American Institute of Architects, American Institute of Electrical Engineers, American Society of Mechanical Engineers, American Street Railway Association, Factory Mutual Fire Insurance Companies, National Association of Fire Engineers, National Board of Fire Underwriters, National Electric Light Association, Underwriters' National Electric Association.

This position, after considerable argument, was sustained, and as a result of the efforts of your committee, assisted by the committee from the Association of Edison Illuminating Companies and the American Institute of Electrical Engineers, the underwriters removed many of the objectionable features in the proposed changes of the rules.

The re-establishment of a conference — after an inactivity of five years or more — to settle finally all questions of rules of the National Electrical Code is of prime importance to the central-station companies of the country, and it will prevent the establishment of rules by the underwriters that might seriously injure the electrical interests of the country and retard the development of the industry.

The necessity for closer relations with other associations of kindred character was shown by the joint work of the committees of the National Electric Light Association and the Association of Edison Illuminating Companies, in the matter of the National Electrical Code. The American Institute of Electrical Engineers, whose membership is made up largely of purely technical men, may lay down some rules, or the National Bureau of Standards may adopt some standards of measurement, which, while they may appear good from a purely scientific standpoint, may be exceedingly bad from the business standpoint of the members of this association.

Some of the members of this association are also members of the Association of Edison Illuminating

Companies and the various state gas and electric light associations throughout the country, and the officers and engineers of the member companies are members of the American Institute of Electrical Engineers, and of the American Society of Mechanical Engineers, and other similar societies, so that if the influence which it is possible for them to wield is brought to bear on any given subject affecting them, and under consideration by other bodies, there is no doubt that serious injury to the interests of the member companies of this association may thereby be prevented. I would recommend to you, therefore, the appointment of a small committee of forceful men to watch the movements of other kindred bodies and engineering societies, to confer with them from time to time, and to promote a closer relationship with them, so that their actions may not be antagonistic to the members of this association.

There is probably no piece of apparatus in the construction of the central station at the present time, the results of which are awaited with such keen interest by central-station managers as the steam turbine. We have arranged for the presentation of a paper on this subject by a man who has had much experience in the operation of one type of turbine, and the discussion will be led by others who are especially versed in the subject, as far as they, as manufacturers, have been able to acquire knowledge. Yet I feel that we shall not have exhausted the subject at the close of this convention, and when we stop to consider that two manufacturers of steam turbines in this country have taken orders in 12 months for approximately 540,000 horse-power capacity, you may realize what an important factor it may ultimately become in our business. It seems wise, therefore, that we should not rest with the information these distinguished gentlemen may give us at this convention, but we should appoint a committee of three good mechanical engineers to follow the development of the steam turbine during the coming year, and report the results at the next convention.

There is a growing demand for electric power in factories, and it is important to central-station companies that this business should be obtained for their service. Statistics showing the useful and economical application of electricity in factories, together with costs at various rates per kw-hour, are not readily obtainable, and I would recommend the appointment of a committee of three men from different sections of the country, to gather statistics on "purchased electric power in factories," and report at the next convention, or sooner, if found feasible.

In choosing the papers for this convention, I have tried to touch upon each branch of the central-station business treating of some phase of production, by-products, distribution, customers' apparatus, engineering and testing, and management. It has been my intention to avoid confining the papers and reports entirely to purely technical subjects, and to treat with considerable liberality questions which might properly be classed under the management of the central station. Many of the subjects to be presented are entirely new to this association, and have never been discussed before in our conventions.

To the gentlemen who have so kindly contributed papers, and to the editors and reporters of the various committees whose names appear on the programme, and to those gentlemen, members of other active committees, who by their valiant support have helped me conserve the interests of the members; to our industrious and ever-watchful assistant secretary, who so ably handles the routine work, and to the electrical press; to all of these who have been of such assistance to me in administering the affairs of the association as its president, I am deeply grateful, and to them I extend my most sincere appreciation.

On motion of Mr. Doherty, it was voted to refer the address of the president to a committee of three for consideration and report at a later meeting.

President Ferguson announced that this committee would be appointed at a later session.

ANNOUNCEMENTS

President Ferguson announced that the secretary, Mr. James B. Cahoon, had been compelled to resign his office on account of ill health. The president had, therefore, appointed Mr. Ernest H. Davis, of Williamsport, Pa., to act as secretary until the expiration of the term, June 1, 1903, when the incoming president would appoint a permanent secretary.

Secretary Davis then read letters of regret from the following named gentlemen:

James B. Angell, President University of Michigan, Ann Arbor, Mich.

Edward A. Birge, Acting President University of Wisconsin, Madison, Wis.

Henry T. Bovey, McGill University, Montreal, Canada, Honorary member.

L. P. Breckenridge, University of Illinois, Urbana, Ill.

Charles F. Brush, Cleveland, Ohio, Honorary member.

Henry S. Carhart, University of Michigan, Ann Arbor, Mich.

S. T. Carnes, Memphis, Tenn., Past-President of the Association.

Charles R. Cross, Massachusetts Institute of Technology, Boston, Mass.

H. J. Davies, Cleveland, Ohio, President Street Railway Accountants' Association.

Louis Duncan, Massachusetts Institute of Technology, Boston, Mass.

Samuel A. Duncan, Atlanta, Ga., Past-President of the Association.

Thomas A. Edison, Honorary member.

M. J. Francisco, Rutland, Vt., Past-President of the Association.

C. M. Goddard, Boston, Secretary Underwriters' National Electric Association.

P. G. Gossler, Montreal, Member of Executive Committee.

Frank W. Gunsaulus, President Armour Institute of Technology, Chicago.

William R. Harper, Chicago, President The University of Chicago.

Carl Hering, Philadelphia, Past-President American Institute of Electrical Engineers.

A. E. Kennelly, Hartford University, Cambridge, Mass.

W. H. Merritt, Chicago, Electrician National Board of Fire Underwriters.

J. F. Morrison, Baltimore, Past-President of the Association.

C. H. Mortimer, Toronto, Canada, Secretary Canadian Electrical Association.

Frederic Nicholls, Toronto, Canada, Past-President of the Association.

Edward L. Nichols, Cornell University, Ithaca, N. Y., Honorary member.

J. H. Perkins, Youngstown, Ohio, Member of the Executive Committee.

Charles F. Pritchard, Lynn, Mass., President Association of Electric Lighting Engineers of New England.

Henry S. Pritchett, President Massachusetts Institute of Technology, Boston, Mass.

William L. Puffer, Massachusetts Institute of Technology, Boston, Mass.

Harris J. Ryan, Cornell University, Ithaca, N. Y.

George D. Shepardson, The University of Minnesota, Minneapolis, Minn.

Nikola Tesla, Honorary member.

Elihu Thomson, Lynn, Mass., Honorary member.

R. H. Thurston, Cornell University, Ithaca, N. Y.

C. R. Van Hise, University of Wisconsin, Madison, Wis.

Edwin R. Weeks, Kansas City, Mo., Past-President of the Association.

C. J. H. Woodbury, Boston, Mass., Secretary New England Cotton Manufacturers' Association.

Alden M. Young, Waterbury, Conn., Past-President of the Association.

THE PRESIDENT: The next business before the convention is the report of the editor of progress, Mr. T. Commerford Martin, of New York.

MR. MARTIN: Mr. President and gentlemen: You have copies of this report and I think it is hardly necessary, therefore, that I should inflict upon you the reading of it, as some twenty topics are taken up. The only difficulty I had was to determine, with the advice of some of the officers of the association, as to which topics should be included in the report. I am obliged to Mr. Doherty for sending me a copy of the report of the committee on progress prepared by Mr. Butterworth for the Ohio Gas Light Association, and I was glad to avail myself of the example set in that report. Some of the topics in my report will be covered by papers and discussions that you will have during this meeting, but I felt it my duty to include them. There were some twenty other topics that I should have been glad to include, but having already reached a length of seventy pages I thought it time to stay my hand.

The chief features of presumable interest in the report are comparisons between our own industry and the gas industry; the introduction and application of the Nernst lamp; the possibilities connected with the introduction of the vacuum tube; the possibilities and actualities of electric heating; the present inadequacy of electric motor drive application, and the possibilities connected with the steam turbine. These and sundry other topics you will see treated at greater or less length.

With regard to some of the statistics contained in the report, I was extremely interested and encouraged by the figures relating to the growth of the association, presented by our worthy president. According to the statistics that I have just compiled for the United States Government, we have in this country to-day 3,854 electric-light systems, not necessarily companies. Of these plants or systems, 805 are municipal, leaving some 3,000 central-station organizations at the present time. It would appear, therefore, from the figures presented by our president, that this association to-day contains within its membership over 15 per cent of the available central-station companies that should join. I have studied the statistics of other national bodies, and, so far as I can ascertain, that is an exceedingly if not an extraordinarily high percentage, upon which we may congratulate ourselves and felicitate not only Mr. Doherty but Mr. Ferguson.

With regard to the remark of the president on the purchase of electric current for motor work, I would call attention to the significant fact, brought out in my report, that at the present time, in the manufacturing industries of this country, less than five per cent of the power utilized is electrical. It is incredible that we should secure the other 95 per cent, because concurrently with the introduction of the electric drive must come the water wheels and steam engines that will drive the generators ; but I think you will agree that there lies before us a future whose possibilities we can not estimate or define in the prosecution of our work, connected with the introduction, development and utilization of the electric motor.

At the conclusion of this report you will find a reference to the question of state laboratories, which we have had up in the State of New York. This has been a matter of considerable concern to us, because it has been fostered and fathered by one of the most distinguished electrical engineers in this country. I think I can say that, for the present at least, that somewhat dubious proposition has been set aside. I have included in my report the original draft of the bill, the report having been written some weeks ago; and, so far as I can ascertain, the proposition to found a state laboratory in New York state died in committee, and I trust that the idea will not be revived. If it is revived and should pass into law, there is a great danger, I fear, that every other state in the Union will be annoyed by the institution of a similar state laboratory, whose chief purpose in life, apparently, would be to harass the central-station industry. I venture to hope that I may have served some useful purpose in bringing this measure to your notice. I have no reason to question the good faith of those who introduced and pushed the measure, but I am convinced, with those of my friends engaged in the central-station industry in the State of New York, that there could hardly be any measure more pernicious than that attempted to be put on the statute book.

I am obliged to you, gentlemen, for your attention.

Mr. Martin's report was as follows:

REPORT OF THE COMMITTEE ON PROGRESS

INTRODUCTORY

In view of the fact that the whole National Electric Light Association is itself a committee to report on the advances of the art, when it meets in annual convention, the appointment of a single individual as a Committee on Progress would imply the creation of a somewhat unnecessary office, involving an honor more discreetly evaded than accepted. The fact that the association has attained its prosperous stage of existence after nearly twenty years of activity, without requiring the aid of such a committee, might well be accepted as evidence of its ability to grow in influence, authority and usefulness without extraneous assistance in its work. Moreover, the excellent quality of its later programmes as well as the higher range of the discussions, year to year, might well absolve the reporter from taking his task very seriously.

The committee having been appointed, however, and request having been made for a summary of what has been done in the lighting art during 1902–1903, the attempt will be made to present a brief general review of the situation, statistically and technically, not assuming to do more than bring together facts that should already be familiar to most of the members, and leaving the fuller data available for easy reference. It is needless to say that frequent citation is made from the columns of the technical press, while the transactions of sister societies are quoted occasionally in regard to topics of current interest. Indeed, the most striking fact that emerges in all reportorial work of this review character is the fewness of the subjects and the infinite number of points of view with respect to them. After nearly a score of years of life the association is dealing still with the questions that agitated it when it started, but every one of them is now seen from different angles by younger eyes.

GAS AND ELECTRICITY

From the statistical standpoint, it is evident that the electric-lighting industry has made great progress during the last year, or rather, during the past annual periods brought to account. Since the association met in Cincinnati last May, I have, as special agent for the United States Census Office, issued two bulletins bearing upon the central-station industry, one dealing with the manufacture of electrical apparatus, the other treating of the use of electric motive power in manufacturing establishments. In neither case had any such work been done before, but there is every reason to believe that the organization of the new Department of Commerce will insure the frequent compilation of valuable statistics of this nature in regard to all the branches of mechanical industry and production or use of apparatus. As the transactions of the association up to the present time nowhere include direct or relative statistics in regard to electricity or its allied arts, or its competitors, it may be well to place a few facts on record here, if only as landmarks and guides.

The best indication of progress by a moving vehicle of any kind is for its passengers to note how it overhauls another vehicle ahead or drops out of sight one astern. In this respect, the electric light and power industry has few gauges, but there are some. As an industry, electric lighting can be measured up against gas, and here we have most interesting data. According to the report of Mr. Arthur L. Hunt for the twelfth United States census, the increase in establishments producing gas between 1850 and 1860 was 636 per cent, but from 1890 to 1900 the rate of increase was only 18 per cent. In view of the fact that the latter was a period of great activity in electric lighting, it is remarkable that gas works should have increased from 742 to 877. But this is rather misleading, and, as Mr. Hunt remarks, the indications are that the number of establishments engaged in the industry is not increasing to any considerable extent. While there were 66 new establishments constructed during the last decade, 92 establishments from which reports were received in 1890 failed to make returns in 1900. Of this latter number 47, or over one-half, were not in operation, having been dismantled, closed indefinitely, or changed to electric plants. Of the other 45 establishments, nearly one-third now distribute natural gas; a few failed to make returns for census purposes; and 18 establishments that were reported separately in 1890 have since lost their identity through consolidation. The number of new establishments is certainly small when it is considered that of the 1,653 cities and towns of the United States having a population of 2,500 and over, there were 826 in which no gas was manufactured. Of the 877 establishments shown for the twelfth census, 269, or 30.7 per cent, were operated in connection with the generation of electricity, and it was reported in many cases that the production of gas was attended with an actual loss. Of course, in a great many instances, local mergers and consolidations that have brought the gas and electric interests together have been due to the initiative of the gas properties which have remained in control, but under such circumstances it is by no means sure who is entitled to remark: "We have met the enemy and they are ours."

INCANDESCENT GAS LIGHTING

Lest the electric-lighting manager should be unduly encouraged by the statistics just cited, it may be well to quote here a passage from the progress report by Mr. Irvin Butterworth to the Ohio Gas Light Association this year on incandescent gas street lighting: "Incandescent gas street lighting," he said, "has made great progress during the past five years, especially during the early part of this period, and it is still coming more and more into favor, gradually making headway against electric street lighting and regaining to gas much of this business that it had previously lost. Berlin, with its 32,000 Welsbach street lights, is now said to be the best lighted city in Europe. The growth of this system of street lighting is shown in the fact that in Boston and vicinity there are now in use about 15,000 incandescent street lamps, in Greater New York and vicinity 20,000, in St. Louis 13,000, in San Francisco 5,000, etc., and nearly all of the smaller cities and towns of the country have many of them in use. The city of Liverpool owns an electric-light plant and buys what gas it uses from a private company, and yet the chairman of its lighting committee, replying to a question asked in open council, recently said that the committee did not intend to extend electric lighting in the streets as they had found that incandescent gas was quite as good and much cheaper." Here is food for thought, although not for discouragement. A British officer in the Soudan has remarked that the Arabs there with their medieval methods and weapons are never so dangerous as when half dead.

STATISTICAL GROWTH OF THE ART

Whatever may have been the effect of electric lighting on gas production and use, only encouragement can be found in the direct figures relative to the advances in the arts connected with electrical illumination and power, as well in their statistical aspect as from any other point of view. At the present moment, the new permanent Census Office of the United States is collecting the data of the industry in this country, and but for the fact that the statistics of the electric-railway art were taken up first by that useful department, I should have been able now to present some interesting figures in detail, bringing down to the present time and treating more exhaustively the electric-lighting figures presented in my report of 1901 on electrical manufacturing for the twelfth census. It is to be borne in mind that this is the first time that the government has made the effort to determine the magnitude of our industry. Of course, private efforts have been made occasionally to arrive at a fair approximation of its scope, although on looking through the records I note that it is several years since the association had any figures submitted to it on the subject. The last careful figures compiled, to my knowledge, were made during the second quarter of 1899, when 2,360 central-station companies were shown to be in existence, reporting 280,439 arc lamps, 2,679,432 direct-current incandescents, 5,380,932 alternating-current incandescents, and 1,159,788 horse-power of generating apparatus in their power plants. In addition to these, the fourteenth annual report of the United States Commissioner of Labor in 1899, showed 460 municipal plants in operation. This makes a total of 2,820 plants operated by central-station companies and municipalities. Some indication of the growth of the art may be seen in the fact that last year, 1902, we brought to account for the Census Office work no fewer than 3,854 such plants of all kinds, showing a remarkable increase of not less than 30 per cent in the three years. This is obviously in sharp contrast to the condition of the gas industry, and there is no doubt that the figures of capacity will exhibit at least a proportionate gain. For example, the production of arc lamps during 1899–1900 was actually 158,187, and I note that during 1902 one large manufacturing company reports a production of over 80,000 lamps for the year. Allowing largely for the substitution of the inclosed for the open arc, and for the requirements of isolated plants, it is evident that a rapid central-station increase has been going on; and the same is true of incandescent lamps, of which the output reported in 1899–1900 was 21,000,000 of 16 candle-power. If we allowed that half of these went to isolated plants, and that every socket on central-station circuits took about one lamp a year, we should reach a result at the present time and at a 10-per-cent gain per year, of a consumption by stations of over 12,500,000 lamps a year, in from 12,500,000 to 15,500,000 sockets; or nearly double the connected incandescent load of four years ago. These figures are striking and interesting, even if conjectural. As to arc lighting, it is highly significant of changes in the art that of late years the production of inclosed arcs has been four times as great as of open, and that concurrently with this there has been apparently a great gain in street lighting, for I notice from the returns of the Massachusetts Commission that while in 1901 the number of street open arcs fell off 1,300, the number of inclosed arcs rose 3,724. It may be incidentally worth noting here that in Massachusetts, the same year, the municipal use of electric current—virtually arc lighting—was 28.6 per cent, leaving 71.4 per cent for private service, which would be chiefly incandescent lighting and power work. It is probable, however, that in all large cities the ratio would be different, and on this point the New York Edison company, this spring, while fighting a movement for a municipal arc plant, stated that the public lighting on Manhattan Island was but five per cent of its business.

COMPARISONS WITH ABROAD

Next year, if the association should honor this committee by continuing it, I hope to present many analytical points of interest, but at this juncture we have another means of measuring up our own progress, in observation of what is done abroad. The two most progressive countries of Europe are Germany and England. With regard to the former nation, incomplete but very useful figures are obtainable from a total of 870 stations, of which 475 reported last year. These 475 plants, with an aggregate capacity of 197,061-kw, have cost about $395 per kilowatt; if a mean of $400 is assumed, the capital invested in the total plants of 358,000-kw aggregate capacity, is about $143,000,000. The total number of central stations on April 1, 1902, was, as stated, 870. Of these, 709 are direct-current stations, 684 being provided with storage batteries, their capacity being 150,500-kw, and the combined and storage-battery capacity being 208,800-kw. Twenty-five direct-current stations, with a machine capacity of

6,200-kw, had no storage batteries. Single and two-phase alternating-current systems were used in 45 stations of 30,500-kw capacity. Three-phase currents were in use in 52 stations of 76,000-kw capacity. Combined three-phase and direct-current systems were in use in 50 stations of 87,000-kw machine capacity and 107,000-kw combined machine and storage-battery capacity. Combined single-phase and direct-current systems were in use in 12 stations of 7,500-kw machine capacity and 8,000-kw combined machine and storage-battery capacity. The total capacity of the storage batteries installed in direct-current stations was 27 per cent of the total capacity of the direct-current stations; 58.6 per cent of all stations used steam power, and the machine capacity of these stations was 79 per cent of the total machine capacity of all stations; six per cent of the total number of plants (with a capacity of one and one-third per cent of the total capacity) used gas engines. The water-power plants were 9.65 per cent of the total number, the capacity being 6.75 per cent of the total capacity. As to size, 353 stations have a capacity below 100-kw; 360 have a capacity between 101-kw and 500-kw, 66 up to 1,000-kw, 33 to 2,000-kw, 30 to 5,000-kw, 17 more than 5,000-kw. As showing the preponderance of a few large plants, it may be noted that the total capacity of the 47 plants which had a capacity above 2,000-kw was one-quarter more than all the other 833 stations together. It will be seen that even allowing for difference of population and national wealth, our electric-light and power development compares most favorably with the like status in Germany.

The excellent statistics of the London *Electrician* show 316 central stations in operation in Great Britain at the close of 1902, and 41 in course of erection. The connected load was equivalent to about 17,000,000 lamps of 8 candle-power, or say 8,000,000 lamps of 16 candle-power, a surprisingly good figure, but indicative, perhaps, of an absence of severe competition from isolated plants, such as is experienced in America. The figures given as to cost and price of current are interesting, and suggest the wish that as years go by more and more of such international data will be forthcoming for study. It appears that the mean price to ordinary consumers for lighting and power supply was 8.32 cents per kw-hour in 1900 and 8.12 cents in 1901; for public lighting the price was 4.66 cents in 1900 and 4.72 cents in 1901; and for traction supply 3.52 cents in 1900 and 3.36 cents in 1901. The average total receipts for current for all uses were 7.12 cents in 1900 and 6.78 cents in 1901. The average figure, representing six per cent of the mean expended capital per unit sold, is very nearly equal to the total cost per unit; in other words, of the total charges on the revenue of a concern, half is roughly the total working cost and half the capital charges. Below one and a half million units the output was the most governing factor, while above that output the load factor was comparatively more and more important in its effect on the expenses, especially on the capital expenses. The St. James station in London heads the list with a total cost per unit sold of 4.18 cents in 1901, and the total cost plus seven per cent of the mean expended capital per unit sold 6.52 cents. The corresponding figures for the average values of all the stations were 5.42 cents and 12.02 cents. Before leaving England, I can not refrain from pointing out that according to the statistics just compiled by Mr. Henry Geissel, Spain has no fewer than 639 central stations, or nearly twice as many as England. This remarkable fact may possibly be explained by the numerous water powers available in Spain.

As we have always had active and zealous officers and members from the Dominion, I would like to add a few figures from Canada. Mr. George Johnson, of Ottawa, the Dominion statistician, shows that the number of companies doing business in electricity in connection with lighting, has increased from 259 in 1898, to 312 in 1902. The number of arc lights increased from 10,389 to 12,884 during the same period. The incandescent lamps number 995,056, making an increase of 179,380 lamps over last year and 531,441 over the year 1898. Reckoning each arc lamp as equal to 10 incandescents, the use of electricity as a light giver has developed in Canada during the past four years from 565,505 lamps in 1898 to 1,125,896 in 1902. Of the total 312 companies, Ontario has 195, or sixty-two and one-half per cent. Ontario cities, towns and villages avail themselves of electricity as a light medium to a much greater extent than those of the other provinces. There are over 110 of these communities in which electricity is used for lighting, and of these more than a score operate their own lighting plants. Several cities and towns have more than one plant.

THE STORAGE-BATTERY EQUIPMENT

In the figures above quoted from Germany, one can not but be struck by the extraordinary proportion of stations equipped with storage batteries—684 out of 870, or 75 per cent. No such ratio applies in the United States, although at the Institute meeting in April, Mr. John W. Lieb placed emphatically on record his conviction as to the absolute indispensability of that adjunct. It would appear from the recent census work that out of the 3,665 simple central stations only 51 report batteries, so that a large field remains for missionary effort. In fact, some stations with batteries betray a disinclination to push their use. Mr. Alton D. Adams reported last December the case of a large system of electrical supply with a battery of 140 cells, equal to an output of 952 kilowatts at a five-hour rate, or 33 per cent of the highest average load on the system. The battery, however, carried only 11.9 per cent of this maximum, and only in one month had it attained its possible rate; reaching, also, 20 per cent of the maximum load in another month. While the output from the system had been slightly but steadily growing, the percentage of battery output had fallen off all the time. In the last three months of 1898 the battery furnished 7.6 per cent of the entire output of the system. In 1899 the percentage was 5.4; in 1900 it was three per cent, and in 1901 it was 2.5. It is unfortunate that Mr. Adams did not disclose what happened in 1902. He states, however, that measured by the ratio of kw-hours of discharge to kw-hours of charge in each year, the efficiency had fallen off from 75.6 per cent to 64.6, or 11 per cent in a little more than three years. He also arrives at the conclusion that the cost charges amounted to 6.4 cents per kw-hour for the current delivered by the battery in one of the years cited, and he remarks: "Facts similar to these no doubt have a bearing on the failure of American central stations to adopt storage batteries more rapidly." There must be another side to this, however, and in view of the rapid concentration of systems, the growth of distribution networks, and the increase in the number of sub-stations, it would seem inevitable that there should be a corresponding storage-battery development. Considerably over $4,000,000 worth of batteries was made and sold in this country last year, largely for central power plant uses. Since the economy in the use of a central-station battery is a function of the load curve, it being greater the sharper the peak, and falling off as the peak spreads, the optimist might declare that the conclusion to be drawn from the disparity noted between American and German central stations is that the former operate under more favorable conditions with respect to load curve. We doubt, however, if a difference exists to such an extent as this might imply.

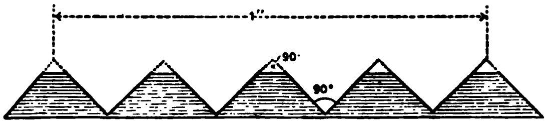
HIGH-TENSION OVERHEAD TRANSMISSION

The recent development of high-tension long-distance transmission of current for purposes of electric light and power has naturally raised many practical questions of interest to central-station men. One of these is brought up in the mechanical specifications for a proposed standard insulator pin presented before the American Institute of Electrical Engineers last March by Mr. Ralph D. Mershon. The data are as follows:

Threaded End—It is proposed to make the diameter of the small end of the pin one inch; the length of the threaded portion is 2.5 inches, and the diameter at the lower end of the threaded portion 1.25 inches, so that the threaded portion will taper from 1.25 inches to one inch in a length of 2.5 inches. The threaded portion of the insulator should have the same dimensions and taper as that of the pin.

Shoulder—It is proposed to make the shoulder three-sixteenths inch on all pins. That is, the diameter of the pin just above the cross-arm will be three-eighths inch greater than the nominal diameter of that portion of the pin in the cross-arm. It is proposed to carry this diameter one-fourth inch above the cross-arm before tapering the pin.

Dimensions in Cross-arm—It is proposed to make the diameter of that portion of the pin in the cross-arm, just below the shoulder, one-thirty-second inch less than the diameter of the hole in the cross-arm and at the lower end of the pin one-sixteenth less than the diameter of the hole in the cross-arm. It is proposed, also, to designate this portion of the pin as having a nominal diameter equal to that of the hole in the cross-arm into which the pin fits. Therefore, that portion of a pin which is to fit a 1.5-inch hole in a cross-arm will have a nominal diameter just below the shoulder of one and fifteen-thirty-seconds inch, and at the lower end of the pin of seven-sixteenths inch.

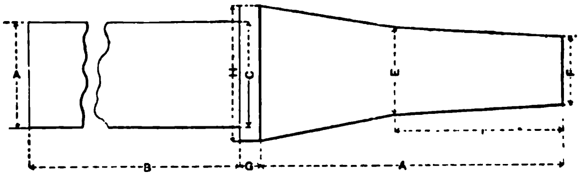


FORM OF PIN THREAD—HIGH-TENSION OVERHEAD TRANSMISSION

Thread—It is proposed to use on all pins a thread having a pitch of one-fourth inch, or four threads to the inch, the form of thread to be that shown in Figure 1 (scale four times full size). As there shown, the angle between the faces of the thread is 90, and the top of the thread is flattened by cutting off, from the form the thread would have if not flattened, one-fourth its unflattened depth. The form of the thread in the insulator should be the same as that on the pin. If this is done it will insure the bearing surface being always on the sides of the threads and never on the edges.

Designation—It is proposed to designate that portion of the pin above the cross-arm as the "stem" of the pin. That portion in the cross-arm as the "shank" of the pin. It is proposed to designate a pin by the length of its stem, *i. e.*, a pin whose stem is five inches long will be designated as a "five-inch" pin, one six inches long as a "six-inch" pin, and so on.

Dimensions of Standard Pins—In accordance with the above, the following table has been prepared, giving a number of sizes of pins and their dimensions, which it is proposed to make standard. The diameter of the shank has in each case been fixed by making it approximately equal to (slightly larger than) the diameter of the theoretical pin corresponding to the length of the stem of the pin in question. The headings of the columns of the table refer to the lettering of Figure 2. Figure 2 is a dimensioned unthreaded five-inch (proposed standard) pin.



Standard Pin—High-Tension Overhead Transmission

Size of Pin	A	B	C Nominal	C Actual	D	E	F	G	H	I
Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
5	5	4¼	1½	1 15/32	1 7/16	1¼	1	¼	1⅞	2½
7	7	4¼	1¾	1 23/32	1 11/16	Same for all sizes of pins.	Same for all sizes of pins.	Same for all sizes of pins.	2⅛	Same for all sizes of pins.
9	9	4¼	1⅞	1 27/32	1 13/16				2¼	
11	11	4¾	2	1 31/32	1 15/16				2⅜	
13	13	4¾	2⅛	2 3/32	2 1/16				2½	
15	15	4¾	2¼	2 7/32	2 3/16				2⅝	
17	17	5¾	2⅜	2 11/32	2 5/16				2¾	
19	19	5¾	2½	2 15/32	2 7/16				2⅞	

In this connection Mr. M. H. Gerry, Jr., of the Missouri River Power Company, favored a diameter greater than one inch at the top of the pin proposed and a thread greater than 2.5 inches. Prof. C. L. Corey noted Californian use of iron pins with porcelain sleeves on the 83-mile, 33,000-volt, 3-phase transmission line from the Santa Ana power house to Los Angeles. He described an iron pin designed by Mr. Wynne for the long lines of the Vancouver Power Company. It consists of a 12-inch steel bolt; a cast-iron sleeve 4.25 inches long fitting closely to the cross-arm filling the space between the thread and corresponding to the stem of the ordinary wooden pin. A lead thread is cast on the end of the steel bolt, which is first chopped or made ragged to enable the lead to hold. Mr. D. L. Huntington, of the Washington Power Company, Spokane, Wash., said that as the result of experiments a pin was adopted 18 inches long made of 1.125-inch round mild steel bar, with a shoulder and shank cast upon it. Mr. C. C. Chesney considered that the success secured in the operation of the great majority of transmission lines is due to the good insulation of the insulator, the insulation of the pin not entering; and that for 40,000 volts and higher, the insulators at present made do not have the same factor of safety as those for lower voltages offered by the same manufacturers. This difference is due more particularly to the general shape of the insulator and the dimensions of the insulating surfaces and petticoats. In localities subject to salt storms, heavy sea fogs or where there are chemical factories there has been more or less pin burning without regard to the type of insulator used or to the potential of the system. In one case, owing to deposit on insulators from a neighboring chemical factory, trouble was experienced from the burning of pins at 440 volts, though 10,000-

volt insulators were used. The evidence, while not conclusive, points to the advisability of using iron pins with modern insulators properly chosen for the line potential. Mr. H. W. Buck said he had found many pins on the Niagara transmission line to Buffalo in which disintegration had taken place at the top of the pin. This would crumble into white powder which, when analyzed, was found to be a nitrate salt. This would appear to indicate that nitric acid was formed by the static discharge of the pin and had attacked the wood. He gave an account of an experimental 75,000-volt, single-phase line, the conductors of which were of iron tied with copper wires. At the end of five months the galvanized iron had turned black, although the iron guy-wires remained in their original bright condition, thus indicating that the blacking was not due to atmospheric conditions. It was noted that the wire became discolored on the surface to the depth of several thousandths of an inch, and the copper tie-wire was also attacked to a certain depth, but not as much as the iron. This would appear to indicate that a nitrogen compound formed in a thin layer around the conductor at high voltage, due to brush discharges, and uniting with moisture, attacked the metal. It was also noted in the discussion that one of the newest lines in Mexico uses Portland cement and iron pins, set upon iron towers giving a distance between the insulators of from 420 to 500 feet.

NEW TYPES OF ARC LAMP

At one time there were thirty or forty "parent" arc-light companies competing for the patronage of members of this association, who, in consequence, had to endure a good deal of rhetoric in regard to the "talking points" of new arc lamps. Although the speculative fever of those early days has died out, and attention is being directed to more recent and radical departures in electrical illumination, one or two special advances in the arc field deserve note. Many members may have heard, for example, of the Bremer arc lamp, but hitherto it has escaped definite record in our transactions. It is the invention of Hugo Bremer, of Germany, and one or two of the lamps have been seen in operation in this country. Herewith is illustrated one of a pair that have been in operation outside the Plaza Hotel, at Central Park, New York city (p. 30). As already described in the technical papers, the principal features of this lamp are the employment of a compound carbon, the arrangement of the carbons at an acute angle to each other, the use of a metal chamber above the arc for reflecting the light downward, and the employment of a magnetic field for the automatic regulation of the arc. The carbons are fed by gravity. When the arc lengthens to or near the breaking point as the carbons consume, an electromagnetically-operated lever—the same which strikes the arc when the lamp starts into operation—re-establishes the arc, and by its motion causes the carbons to feed until the arc reaches the normal length.

Both of the carbons are of small diameter, that of the positive carbon being about seven millimeters, and of the negative carbon six millimeters, or about five-sixteenths and one-fourth inch, respectively. The negative electrode is an ordinary solid carbon, but the positive electrode is a cored carbon of special composition. This carbon contains certain metallic salts in considerable quantity, of which magnesia is one, and also a certain proportion of boron or other material of the same family. In the past, difficulty arose in the use of metallic carbons owing to the fact that they produce scoria, which tends to form an incombustible coating about the points of the electrodes, thereby interfering with or interrupting the arc. A special feature consists in the introduction of boron or similar material as a flux, whereby the otherwise solid scoria is softened or liquefied, thus enabling it to drip off and not interfere with the operation of the arc.

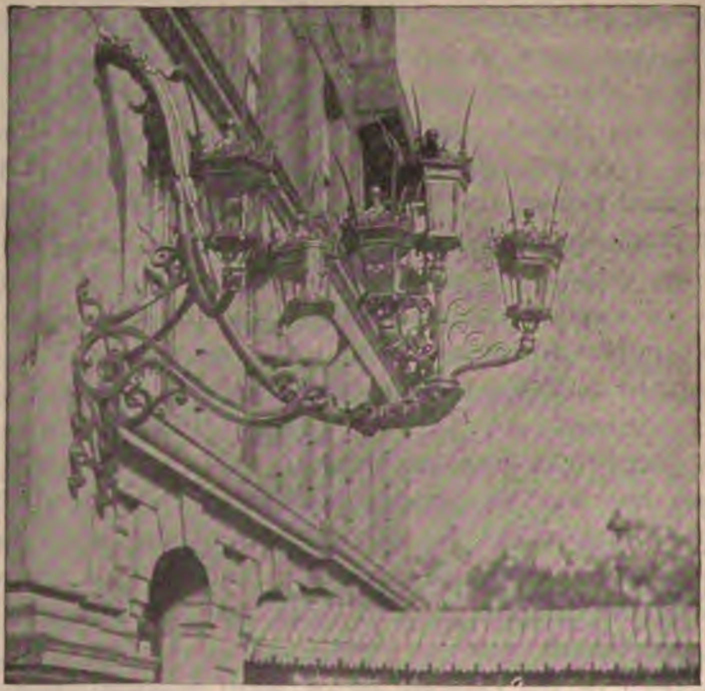


FIG. 1.—BREMER ARC LAMP

The two electrodes are inclined to each other at an acute angle, and the points are surrounded by a metal chamber open below. The magnesium in the positive carbon makes a snowy deposit on the surface of this reflector, thus providing a dull, white, highly-reflecting surface. The coating obtained in this way adheres to the metallic surfaces to the thickness of about one-eighth inch. A very simple arrangement is employed to obtain a magnetic field for the control of the arc. The strength of this field is dependent upon the current flowing through the lamp, which gives an automatic character to the magnetic regulation.

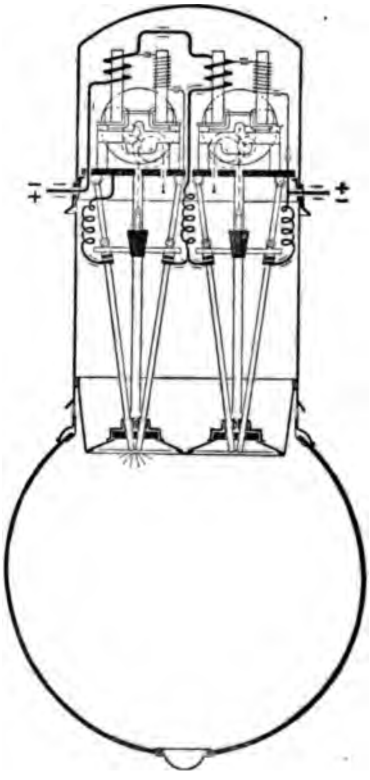


FIG. 2.—DOUBLE CARBON BREMER LAMP

The color of the light can be regulated almost at will by the use of proper materials in the arc. The light from the lamps in service in New York is particularly agreeable, the illumination furnished being between that from an incandescent lamp and that of an arc, lacking much of the redness of the former and the glare of the latter. Some experiments made at the Laboratoire Central de l'Electricité in Paris showed that for a given total flux of light the efficiency of the lamp is about double that of the ordinary arc lamp, the exact ratio being 200 to 117. In view of the fact that all the light is distributed in useful directions, the comparison in the Bremer lamp is apparently very favorable.

This lamp is also made with the carbons vertical to each other as usual, and it is also made along the familiar lines of the double arc lamp, as shown in Figure 2, in which the two main current windings are in series with one or the other pair of carbons; the shunt windings are in parallel with the arc. It follows that all the coils are supplied with current, so that as only one arc is burning there is a slight waste, compensated by greater certainty of action. Several Bremer lamps can also be operated in series.

Another but smaller form of impregnated carbon arc lamp has been devised by an Italian engineer named Rignon, and taken up by well-known German manufacturers. According to the only details I have seen that are authentic, this miniature arc lamp has about the size of a Nernst lamp for one ampere. It is an inclosed lamp. The impregnation of the carbons is said to increase the illumination obtained per unit of power, and prolong the life of the carbon. The regulating mechanism is reported to be very simple, so that a small and very economical lamp is produced, the light from which is said to be steady. The life of the carbons, which have a thickness of about one millimeter, is 20 hours. The current consumption is 0.6 watt per candle-power. Rignon states that the lamp can be made from 50 candle-power upwards, the selling price being not over $5.00.

HIGH-TENSION UNDERGROUND TRANSMISSION

The underground aspects of high-tension transmission were recently summed up by Mr. Henry S. Floy. Basing his conclusion on figures secured from various manufacturers, he estimated that there was expended in the United States during the year 1902, at least $14,000,000 for the purchase of insulated conductors designed for the transmission of electrical energy other than that used in telegraph and telephone service. Of this only a small part, probably not over one per cent, was invested in what may fairly be termed high-tension insulated conductors; that is, conductors which are used for transmitting energy at a pressure of at least 10,000 volts. While the art had made rapid strides in the utilization of higher voltages for electrical transmission until at present 40,000 volts is not considered extraordinary, and 60,000 volts is employed in at least one installation, all of this advance work is being done with the use of ærial circuits, and very little has been accomplished through the use of an insulated conductor in the form of a cable. It is almost possible to count on the fingers of one hand all the installations in the world which are transmitting energy at 10,000 volts, or above, by means of underground cables. This is the more surprising when it is considered that several comparatively high-tension underground systems have been in operation a number of years, that they have given almost perfect satisfaction and that not one of them has proven a failure.

For several years Ferranti has been operating successfully a single-phase, high-tension underground transmission in London. During the past six years the

Twin City Rapid Transit Company, of Minneapolis, has had in constant operation two 11,000-volt, three-conductor cables, respectively ten and ten and three-quarter miles in length. Two and one-half years ago the St. Croix Power Company installed in St. Paul two three-conductor cables, each a little over three miles in length, which have ever since been in satisfactory operation at about 25,000 volts. Buffalo is distributing locally thousands of kilowatts of power from Niagara Falls through 10,000-volt cables. The Montreal Light, Heat and Power Company last autumn put into successful operation a considerable length of 22,000-volt and a few hundred feet of 30,000-volt cable. In New York city the Manhattan Elevated has laid about 12 miles of "unusually high" 11,000-volt cable, part of which has been in satisfactory operation for over a year. The Rapid Transit Underground Railway has installed thus far some 20 miles of tri-phase, 11,000-volt cable, and it is even whispered that the city is to see a 44,000-volt underground transmission in the not distant future.

It will be argued by some engineers that one reason for the slow introduction and small use of high-tension cable is due to the relatively small saving in copper and greater cost in insulation resulting from increasing the pressure. It seemed to Mr. Floy, however, that this conclusion is not warranted, judging from the figures available as to the relative cost of the cables suited for different potentials up to 25,000 volts. Furthermore, such conclusion omits a consideration of the money that may necessarily be invested for transformers, real estate, etc., as for example in the Niagara Falls-Buffalo transmission, where, although 20,000 volts is being used on the overhead line, step-down transformers are interposed to reduce the voltage from 20,000 to 10,000 volts before the current is distributed underground.

MOTORS AND ELECTRIC DRIVE

No branch of the central-station industry has gone ahead with greater activity during 1902 than that of electric-power distribution, due doubtless to the fact that so large an opportunity still exists. The revelations of the twelfth United States census were in this respect little short of extraordinary. In dealing with the manufactures of the country, no fewer than 512,254 establishments or factories came under consideration. The extent to which hand-power is still resorted to, evidencing the opportunity for small electric motors, may be inferred from the singular fact that of these half-million establishments only 169,409 reported power. In other words, in only 33 per cent of the "shops" in the United States had it paid to install ordinary mechanical power, or a gain of only five per cent in 10 years. Steam continued, of course, to be the great primary power and had risen rapidly, being, as the report shows, not less than 8,742,416 horse-power in 1900 out of a total of 11,300,081 horse-power. This is 77.4 per cent, whereas in 1890 it was only 51.8 per cent. Water-power, on the other hand, has gone off; for, although it has risen in bulk from 1,255,206 horse-power to 1,727,258, the percentage of the total in 1900 was only 15.3 as compared with 21.1 in 1890.

It appeared further that the electric power owned and rented for manufacturing work was only about four per cent of the total, the figures being 311,016 horse-power owned, in 16.923 motors, and 183,682 horse-power rented. But this showed a gain of 1,897 per cent over the figures of 1890, when the electric motor had not fairly come in. Moreover, the fact deserves note that while electric power rented was 183,682 horse-power, all other power rented was only 137,369 horse-power. In the early days of the motor it was proposed to rent out all the motors as a means of introducing them, and the practice gained considerable vogue, as shown by my paper read before the association in 1886; but as the above statistics prove, people now buy and own their motors, and the Companies are not burdened with an investment it would have been extremely difficult to maintain free from enormous risk of detriment and depreciation. What this would have meant may be inferred from the statement that in 1900–1901 the New York Edison company reported 50,634 horse-power of motors connected to its circuits, or 30 times as much as in 1890. At $75 per horse-power, this would imply an investment by the company of nearly four millions in machinery that it would have had to watch over widely scattered territory. Obviously, the plan of selling motors outright has not checked their adoption, in view of such phenomenal increases.

It is, of course, evident that central stations have many fields for work with motors, outside those connected with factories, so that, great as are the opportunities there, they are not the only ones. At the recent meeting, for example, of that useful body, the Iowa Electrical Association, I note that Mr. D. F. McGee, of Red Oak, gave some interesting data on city pumping. It appears that 20 electric-light companies in Iowa are doing city pumping for waterworks, and five of these are doing it with electrically-operated pumps. Nine of these stations pump at a flat rate of so much per month. Ten have a minimum rate with a measured rate for all pumping over a certain daily maximum. One pumps at a regular rate of so much per gallon. Mr. McGee thought that many members were either inexperienced in this class of work or were unable to secure definite information as to cost of doing it when they made their contracts for pumping. "As a result, we are doing it at a loss. Our company was one of the first in the state to attempt to do city pumping with electric power. We have been successful in saving money for the city, but our margin of profit, after figuring up cost of fuel and other expenses, interest on investment and depreciation, has not been very large. We furnish day power service and operate a heating plant; have a large standpipe and can pump water at most convenient times." The rate at Red Oak is $125 per month minimum, with four cents per gallon additional for all in excess of 100,000 gallons each day. The pumps work against 100 pounds pressure, drawing from open wells. Allowing six-per-cent interest and six-per-cent depreciation on the apparatus, the rate received worked out practically at about four cents per kw-hour. The saving to the city was $1,800 to $2,000 per year. Mr. A. W. Zahn, of Mason City, said his company had been recently figuring with the city on doing the pumping, as the city's apparatus was in need of replacement. It was now costing the city eight cents per 1,000 gallons to pump from a deep well and then to a standpipe.

Another branch of work now being pushed very vigorously in the large cities is that of elevator service, and what can be earned in that direction is shown by the following table compiled by the Brooklyn Edison company. It shows the average monthly earnings of the company for the past year on 25 electric passenger elevators and 25 electric freight elevators.

PASSENGER ELEVATORS			FREIGHT ELEVATORS		
No.	Horse-power	Cost per Month	No	Horse power	Cost per Month
1	7½	$8 64	1	5	$5 52
1	7	17 98	1	7	4 32
1	8	21 59	2	20	22 93
1	7½	34 26	1	5	8 86
1	5	10 95	1	7½	2 88
1	7½	10 37	1	5	5 40
1	6	31 47	1	5	24 28
1	12	12 19	1	7½	7 89
1	7½	15 74	1	5	1 80
1	15	48 22	1	10	4 68
1	12	31 53	1	7½	3 96
1	5	24 55	1	7½	4 32
1	7½	15 36	1	7½	32 26
1	6	7 24	1	5	5 72
1	6	5 64	1	7½	5 40
1	6	4 92	1	7½	2 40
1	5	14 50	2	20	25 85
1	15	22 94	1	7½	8 86
1	12	23 51	1	10	29 16
1	7½	5 16	1	4	9 29
1	10	8 32	1	7½	20 16
1	8	9 98	1	10	13 15
1	15	20 58	1	7½	6 27
1	10	4 80			
1	10	22 93			
25	218	$433 37	25	186	$255 36

Average cost per month per passenger elevator, $17.33.
Average cost per month per horse-power, $1.98.
Average cost per month per freight elevator, $10.21.
Average cost per month per horse-power, $1.37.

An indication of the enormous activity in motor production and use is found in the fact that during 1902 the General Electric Company alone reported the manufacture of 16,000 stationary motors, and an increase of 40 per cent in electric-motor-drive applications.

ADVANCES IN ELECTRIC HEATING

In discussing the subject of electric heating with central-station men, the remark is still often heard that the cost of purchase and operation places it beyond the category of large sources of income; and the private customer also very often abstains from the use of such apparatus because of the fear that it will cost too much. There is a third party in interest, the manufacturer of such apparatus, who is fighting all the time for a lower kw-hour price; and it is obvious that the lower the cost of current the greater will be the public patronage extended to any and every class of electrical service and appliance. I can well remember that cost of current was the burden of complaint in the early days of the motor, but to-day every intelligent manager is aiming to increase his motor load, and with concessions to the consumer that are doing much to build up that class of business. In the meantime, many a manager is having electric heat appliances put on his circuits without knowing much about it, so that the public often finds it convenient to pay for temporary heat the price of light. Paradoxical as it may sound, the crying demand is for heat in summer, which largely goes unsatisfied, and will remain a want until the electrical inventor and manager have solved the problems in a manner that will enable a woman to cook electrically as easily as she now throws a shawl over her shoulders, or permit a man to warm up his office as promptly as he can don a light overcoat.

At Somerville, Mass., recently, the central-station manager, in reconstructing, cut off circuits in resident sections a street at a time, from day to day, when light would not be required. His first experience was that he got five complaints from one street. The people had no current—and they must have it—because they could not use their flatirons. Yet the manager had not sold a single flatiron at that time and did not have the means of knowing that any were thus being operated. Mr. James I. Ayer, our worthy past president, now manager of the Simplex Electric Heating Company, informs me that he, also, knew of no such use specifically in Somerville. In this case we have an example of what must be going on all over the country, for Mr. Ayer states that they have made and sold over 60,000 flatirons, of which, in New York alone, we have, by the way, some 5,000. What is true of flatirons must be true of other appliances, for Mr Ayer tells me that last year alone they disposed of about 1,000 chafing dishes; and I think it stands to reason that a great many of these must be operated on central-station circuits. Perhaps, as I have intimated, we are beginning to do more collectively than, as individual stations, we imagine to be the case. Seeking for information in this respect, I have learned from Mr. Ayer that their customers' index carries about 10,000 names, about 20 to 25 per cent of which represent factories, hospitals and public institutions. Putting aside jobbers, contractors and retail dealers, it is evident that central stations are proportionately well in evidence; and in this connection I can only mention with high praise the special showroom demonstration equipments fitted up by the Boston Edison company, Chicago. Edison company, New York Edison company, Hartford Electric Light Company, Memphis Electric Light Company and others. At Minneapolis and St. Louis, the electric-lighting companies distribute advertising matter in relation to electric heating, furnished by a local supply house that maintains exhibition rooms.

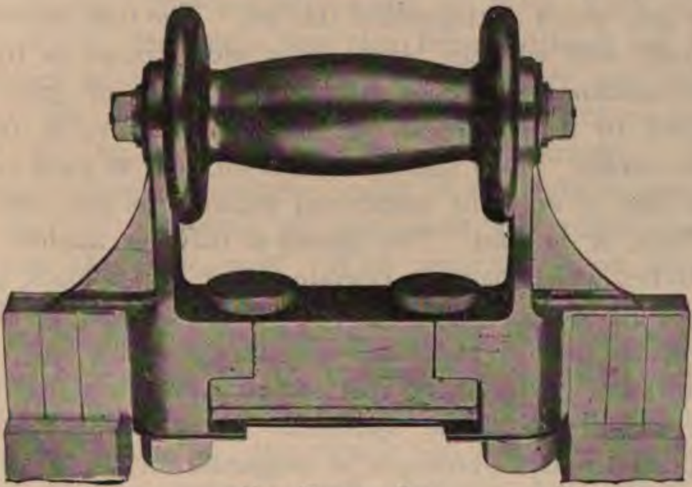
It may still seem to some central-station men that this is "picayune" business, but heating is apt to run up into the consumption of large volumes of current; and there is a growing inquiry for special work and equipments through central stations. In one instance, the recent supply of a 15-kw heater for an oil tank enabled the central station to get the motor business also by being able to take care of the other want. Mr. Ayer states that they have installations of as many as 50 electric glue pots operated on central-station current; and the number of such pots is already "way up" in the thousands. In this respect also, Mr. Max Loewenthal, engineer of the Prometheus Electric Company, informs me of three cases within the month of April where the settlement of important industrial heating questions enabled the stations to secure large contracts for current; one being a rubber company using heat for dies; one a paper-box company using large glue pots; and one a cigar factory using electrically-heated branding tools.

All this is encouraging, but I am free to confess my present dissatisfaction with the slowness of development in the domestic field as compared with gains in the industrial. If we assume hypothetical cases, it would seem that a great deal more could be done even now. Under a sliding scale of prices, whatever current is consumed for heating, cooking or laundry purposes, counts toward reducing the price for all the current used. It is easy to see that this tends at once toward economy. In fact, it is possible, if one takes an extreme case, almost to save money by adding an electric kitchen to the household. Let us assume that a flat contained 16 electric lamps, and that their total consumption was estimated at 800 watts an hour. Now let us also suppose that they actually consumed 47 kilowatts a month, which would be just within the two-hour-a-day limit, and still subject them to the charge of 15 cents a kilowatt. The monthly bill would be $7.05. Now, assume that an electric kitchen has been added which uses 3,300 watts a day. This would be 99 kilowatts a month. If paid for at 15 cents a kilowatt, the kitchen alone would cost $14.84 and the whole bill for currrent would be $21.89 for the month. As a matter of fact, however, the total consumption of current would have amounted to 146 kilowatts, or more than six times the hourly capacity of the lighting installation, and the whole bill would be at the rate of five cents a kilowatt. The total charge would then be $7.30, or a cost of 25 cents only a month for the cooking. Unless there is something very much amiss with this calculation beyond my power of detection, such figures involve a revolution in domestic economy that we must come to sooner or later.

IMPROVEMENTS IN FUSES

One of the important details of construction and operation is the fuse, an item upon which a considerable amount of successful work has been done in this country. It is from England, however, that we have recently received the most striking novelty in this class — a novelty which exemplifies in a curious manner the close, immediate effect that advances in one field of industry have upon others totally dissimilar. The device here shown has been in practical use for some time past by one of the large English electric light and power companies, the London Electrical Supply Corporation, and belongs in the "Sparklet" group of inventions.

As you are probably all aware, sparklets are small steel capsules, about as large as an olive, containing liquid carbonic acid gas. The necks are closed with thin steel stoppers, made gas-tight for a pressure of 600 pounds per square inch, with a thin rubber ring. They are commonly used for the purpose of aerating water in siphons, a simple attachment to the latter enabling the user to pierce the stopper of the sparklet, so as to release the gas. They are readily obtained in boxes of 12 from drug stores, etc., and are inexpensive. The sudden expansion of the carbon dioxide as it flashes into gas, produces a temperature in the neighborhood of 100 Fahrenheit below zero. The gas itself, by its incombustible nature, tends to extinguish flame, and at the same time the violence with which it is ejected from the sparklet, as though the latter were a small cannon, acts as a blow-out device of the highest efficiency. One type of fuse is intended for the high-pressure side of transformers. The body is a trough of earthenware, with a recess at each end near the terminals. The fuse consists of a number of fine copper wires inclosed between strips of mica for the greater part of their length, and exposed near the ends. The fuses are made up with metal terminal plates ready for immediate insertion into the trough.



NEW TYPE OF FUSE.

Two marble blocks fit into the recesses in the earthenware. In each of these there is a hole shaped in such a way as to receive the body of a sparklet, while allowing its neck to project slightly beyond the surface at the side next to the fuse-gap. When these blocks are slipped into place the sparklets are held in position by spring clamps projecting from the terminals of the fuse so as to insure their connection with the circuit. Directly the fuse has blown, the arc which follows rises, passes on to the end of one or both of the sparklets, fuses the stopper, and releases the gas, which extinguishes the arc. The fuse operates equally well whether blown by a short circuit or by a long-sustained excess of load. The length of gap required to deal with an arc of 10,000 volts is only nine inches. Two sparklets are used, one at each end, but this is only for additional security, as one always suffices, it is said. The sparklets may be applied to switches which have to operate under heavy loads, and are quite applicable to 500-volt circuits. The lighting company has, in fact, employed them in this way, the sparklet being so placed that the arc formed on opening the switch opens the sparklet. When the system is applied to circuit-breakers, a magazine of the revolver type is employed, by means of which a fresh sparklet is brought into position every time the switch is closed. The fuses for low-tension work are made in several standard sizes for currents up to 1,000 amperes and pressures up to 500 volts continuous current.

VACUUM-TUBE LIGHTING

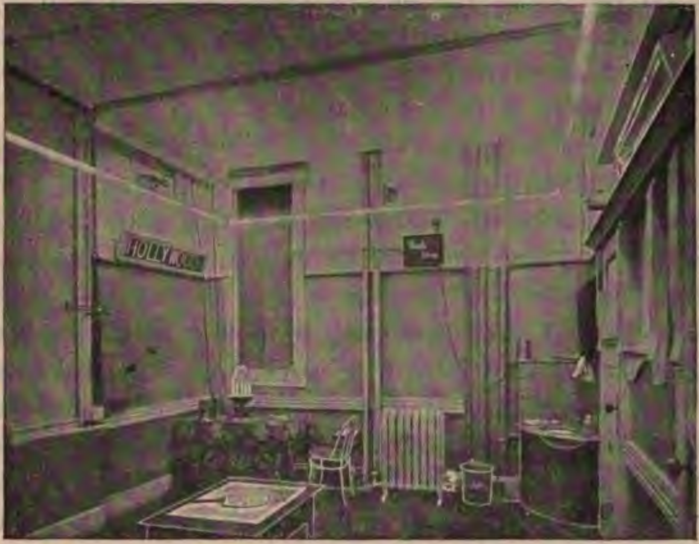
From the very first demonstrations, this association has followed with interest the development of vacuum-tube lighting; and at the successful exhibitions that have been held under its auspices the best displays ever given in this country have been seen. Our transactions include the personal reports of that distinguished pioneer, Mr. Nikola Tesla, as to his own brilliant studies in this direction, and have also embraced the data of other able experimenters and inventors. Of late, attention has been paid chiefly to the work of two men, Mr. D. McFarlan Moore and Mr. Peter Cooper Hewitt. The latter has worked with mercury-vapor tubes, on direct-current incandescent circuits, and the results have been so favorable that tubes of this type are now in regular service for commercial photographic work in New York city. Mr. C. P. Steinmetz has also been working on this subject in improving the Arons mercury arc lamp, and has been lighting his house at Schenectady, N. Y., by mercury arcs of this character. The ghastly "greenery-yallery" color of the light is against it, but an efficiency of half-a-watt per candle-power is not to be despised. With respect to these lamps, Mr. Steinmetz says:

"Extended investigations showed that the harmful physiological effects of light, as observed when working for a long time with artificial illumination, are not due to the lower intensity of artificial illumination compared with daylight, but rather to the red and orange rays which predominate in the artificial illuminants. These harmful effects disappear by excluding the red and orange rays. The mercury arc, therefore, is the only known artificial illuminant which is perfectly harmless, and thus especially suited for use where accurate work has to be done by artificial illumination, as in drafting rooms, offices, factories, etc. In this respect it differs from the Welsbach gas light, in which the greenish color is due to an excess of green rays superposed upon an excess of red and orange rays, and which, therefore, do not have the same harmless feature.

"A strongly noticeable feature of the mercury arc is its penetrating power regarding distance. While the intensity of radiation obviously decreases for all colors proportionally to the square of the distance, the sensitivity of the eye with decreasing intensity decreases much faster for red than for green and blue rays, so that the apparent physiological intensity of bluish-green light decreases with the distance much slower than that of red light; that is, of a red and green light of equal intensity the red light will appear much more intense and glaring at a short distance, while the green light will appear much more intense at a greater distance.

"For color matching, however, the light of the mercury arc is unsuitable, as is also that of the gas or kerosene flame, only that with the latter the blue appears blackened, while with the former the red appears brown and the blue retains its full brilliancy. The mercury gives especially brilliant effects wherever green is the preponderating color and is thus best suited for suburban street lighting, lighting of country seats, greenhouses, etc. The suppression of the red color gives all vegetation an especially vivid and fresh appearance, and the strong actinic character of the light gives a fluorescent sheen to many substances usually not recognized as fluorescent, such as glass, snow, etc. For indoor illumination in private residences the mercury arc is, owing to its color, not well suited except when there is added to it the red and orange rays. This, however, lowers the efficiency owing to the inherently lower efficiency of red and orange light. The mercury arc can be operated on alternating-current as well as on direct-current circuits, though thus far most of the development has been done in the line of direct-current."

Mr. Moore's work has also reached a stage of practicality that brings it well within the purview of this association. I show herewith a picture of an office that he has been lighting for some months past in New York city with one continuous vacuum tube disposed around the room like a moulding of glass. The room measures 18 feet 4 inches by 13 feet 5 inches. The ceiling is 11 feet 9 inches in height. The walls of the room are buff-colored for a distance of 7 feet 7 inches above the floor and above that are white. The three doors and door trims are white. The floor is painted dark brown, with a rug having a dark brown and buff-colored pattern. The vacuum light tube is one and seven-eighths inches in diameter and is run around the room supported by six side



ROOM LIT BY ONE LONG VACUUM TUBE—(Photographed by the Light of the Tube).

brackets at a height of 9 feet 6 inches above the floor and at an average distance of about 13 inches out from the wall. The total length of the exposed vacuum tube is approximately 55 feet. The tube is in one continuous length and its terminals enter a box placed near the ceiling, which contains a special high-voltage transformer, for which current is obtained from an inductor type alternator designed by Mr. Moore, direct-connected to a 3-hp direct-current motor run off the local Edison 220-volt street mains at 175 r.p.m. The alternator gives 57,600 alternations per minute or 480 cycles per second, with a potential of 40 to 50 volts at its terminals.

The wires from the alternator are led to the special transformer, to which the tube is connected, and having a ratio of 1 to 100, so that the potential delivered to the caps of the vacuum tube is approximately between 4,000 and 5,000 volts. The tube shown around the ceiling is built up from standard lengths of about eight feet, which are joined *in situ* by simple and handy devices that Mr. Moore has worked out for the purpose, so that any length with any angle of bend can be made and run in a very few hours. As installed and tested by a well-known electrical engineer, whose report I have seen, good illumination is produced by the tube with 3.9 watts per candle, and brilliant illumination with 4.8 watts. My own observation of the lighting is that it is very satisfactory, the color being pure and cheerful and the diffusion perfect, as in a studio with proper north exposure in bright sunshine.

On the table and sideboards in the room are seen several devices, while on the walls are various signs, operated by means of the Moore vacuum-break vibrator and coil contained in a nickel-plated box, eight inches high by four and one-half inches in diameter over all. These vibrators are connected directly to the 110-volt Edison street mains that serve the office building, by means of the usual plug. The signs are very pretty and attractive, and, it would seem, might well be made a great advertising novelty, as well as a feature of spectacular displays of a kindred character. It is such work as this that makes me believe in the imminence of commercial vacuum-tube lighting, toward which so much encouraging effort is now being directed by the inventors above named as well as by others at present less conspicuous.

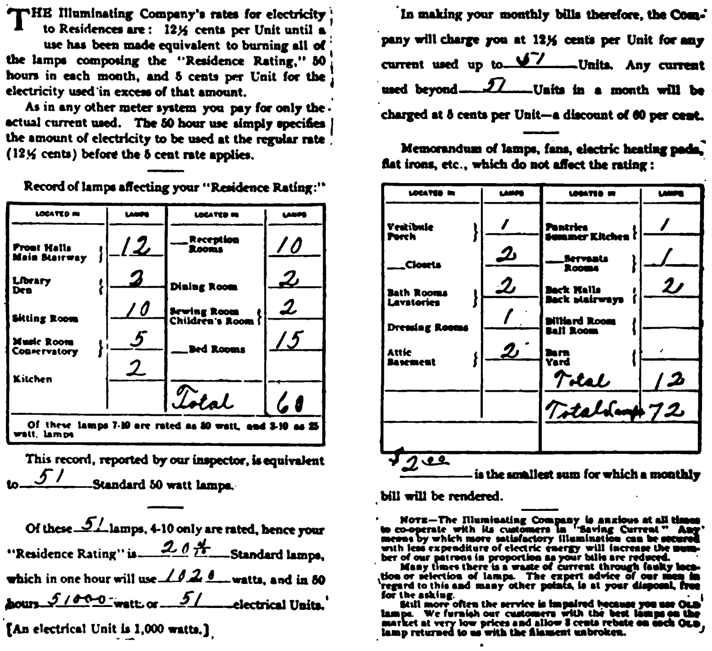
METHODS OF CHARGING FOR CURRENT

From time to time the association has paid considerable attention to methods for charging for current, and while there remains a good deal to be said on the subject, the discussion somewhat lacks novelty. It is encouraging to note a tendency toward a general reduction in the price of current throughout the country, in spite of the higher cost of fuel. In New York city the local Edison company has made, during the past year, the third in a series of reductions, bringing the maximum price of current down from 20 cents to 15 cents per kw-hour. This reduction is, in many cases, as much as 25 per cent from former bills, and will amount to nearly $400,000. The new scale was put in force voluntarily by the company in question.

As to the "demand" system, its advocates remain active, and an instance of its vindication is afforded by Belfast, Ireland, where certain influential consumers became dissatisfied with it, and the electricity committee asked the borough electrical engineer, Mr. M'Cowen, to report on the subject. His report was in favor of the Wright system and recommended its retention. Mr. M'Cowen strongly recommended refraining from the contemplated change from the "demand-indicator" to the "flat-rate" system. He gave statistics to prove that the long-hour consumer at a low average price per unit brings more profit to the undertaking than the short-hour consumer at a high average price per unit. The former ought, therefore, to be encouraged by the retention of the demand system. He showed by diagrams that the same capital expenditure is required to supply 20 units at the peak load as to supply 2,400 units spread over the whole 24 hours, and that short-hour consumers are an actual loss to the undertaking, while long-hour users, paying the lowest price, are the most profitable. He was strongly against the introduction of a general flat rate, but thought that such a movement for domestic purposes might be worth consideration, as the maximum demand of private houses occurs at a later hour than in the city.

Attention has recently been called to the fact that the Cleveland Electric Illuminating Company, of Cleveland, Ohio, is charging for current on what it terms a "two-rate" system. This is not the two-rate meter system with which managers are probably familiar, but derives the name "two-rate" from the fact that electrical energy is charged for at one rate until an amount of electrical energy has been used equivalent to burning all of the lamps a certain number of hours. The rates are 12.5 cents per kw-hour, until an amount of electrical energy has been used equivalent to burning all of the lamps connected to the meter 50 hours in each month. The rate is five cents per kw-hour for all energy used in excess of that amount. As in any other meter system, the customer pays for only the actual amount of current used. This 50-hour-use rule simply specifies the amount of electricity to be used at the regular rate of 12.5 cents, before the five-cent rate begins to apply. This arrangement, however, is somewhat modified for residence lighting. In making the residence rate, only 40 per cent of the lamps connected to the meter are counted as a connected load, from which to calculate the 50 hours' use per lamp, upon which the two rate system is based. This is considered fair to both customer and company, because a residence seldom has all its lamps lighted at the same time. On special occasions a large number of the lamps are lighted simultaneously; but experience shows that, when such is the case, less than the usual amount of light is used in several other houses; and for this reason only 40 per cent of the lamps connected to the meter are reckoned as connected load in making the meter rate. Further than this, lamps connected in closets, servants' quarters, attic and basement, are left out of the residence count.

In making up the residence rating, a card is used, on which are marked the lamps affecting the residence rating, and the lamps, heating pads, flat-iron heating, etc., which do not affect the rating. Mr. S. Scovil, the well-known vice-president of the company, has given the question of rates much thought, and has some clear and forcible ways of presenting the justice of a system of rates where the investment and readiness to serve charges are properly taken care of. In regard to this method, it is worth while to quote Mr. Scovil, who says: "The system of billing for current according to the lamps connected, as is done by the Cleveland company, requires an inspection department, which is a source of some expense. In business places this inspection has to be thorough, and made at no infrequent intervals. In residences, however, we find that, after the lamps have once been installed, it is but seldom that any changes occur in the installation, so that there is little or no inspection required in the residence part of the business. If a residence makes any material change in the lights installed in it, the attention of the meter reader is likely to be called to the fact when making his rounds, or the accounting department may have its attention called to it because of the increased use of current. We were led to adopt this differential rating system for residences partly because of the desire to avoid the investment in demand meters, but more particularly because of the fact that we did not want to take upon ourselves



THE Illuminating Company's rates for electricity to Residences are: 12½ cents per Unit until a use has been made equivalent to burning all of the lamps composing the "Residence Rating," 50 hours in each month, and 5 cents per Unit for the electricity used in excess of that amount.

As in any other meter system you pay for only the actual current used. The 50 hour use simply specifies the amount of electricity to be used at the regular rate (12½ cents) before the 5 cent rate applies.

Record of lamps affecting your "Residence Rating:"

LOCATED IN	LAMPS	LOCATED IN	LAMPS
Front Halls Main Stairway	12	—Reception Rooms	10
Library Den	2	Dining Room	2
Sitting Room	10	Sewing Room Children's Room	2
Music Room Conservatory	5	—Bed Rooms	15
Kitchen	2		
		Total	60

Of these lamps 7-10 are rated as 50 watt, and 3-10 as 25 watt. lamps

This record, reported by our inspector, is equivalent to 51 Standard 50 watt lamps.

Of these 51 lamps, 4-10 only are rated, hence your "Residence Rating" is 20 4/10 Standard lamps, which in one hour will use 1020 watts, and in 50 hours 51000 watts or 51 electrical Units.

[An electrical Unit is 1,000 watts.]

In making your monthly bills therefore, the Company will charge you at 12½ cents per Unit for any current used up to 51 Units. Any current used beyond 51 Units in a month will be charged at 5 cents per Unit—a discount of 60 per cent.

Memorandum of lamps, fans, electric heating pads, flat irons, etc., which do not affect the rating:

LOCATED IN	LAMPS	LOCATED IN	LAMPS
Vestibule Porch	1	Pantries Summer Kitchen	1
—Closets	2	—Servants Rooms	1
Bath Rooms Lavatories	2	Back Halls Back Stairways	2
Dressing Rooms	1	Billiard Room Ball Room	
Attic Basement	2	Barn Yard	
		Total	12
		Total Lamps	72

$2.00 is the smallest sum for which a monthly bill will be rendered.

NOTE—The Illuminating Company is anxious at all times to co-operate with its customers in "Saving Current." Any means by which more satisfactory illumination can be secured with less expenditure of electric energy will increase the number of our patrons in proportion as your bills are reduced.

Many times there is a waste of current through faulty location or selection of lamps. The expert advice of our men in regard to this and many other points, is at your disposal, free for the asking.

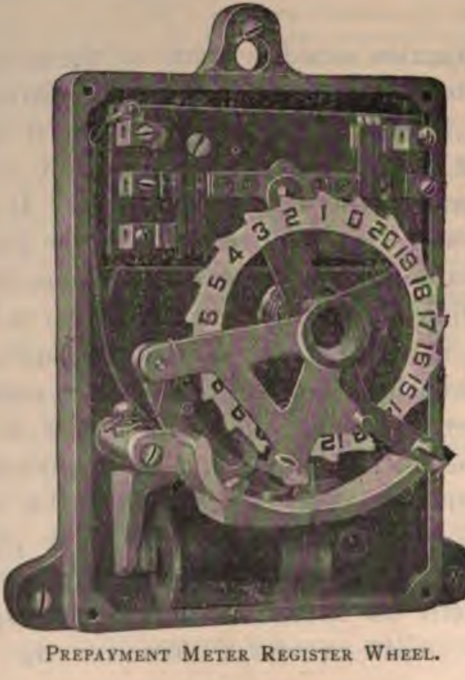
Still more often the service is impaired because you use OLD lamps. We furnish our customers with the best lamps on the market at very low prices and allow 8 cents rebate on each OLD lamp returned to us with the filament unbroken.

CLEVELAND METHOD FOR CHARGING FOR CURRENT.

the additional onus of continually verifying the correctness of any measuring instrument other than the wattmeter. One such instrument is quite sufficient. It may be interesting to know that the result of our method of rating is that we find the total demand, as arrived at by the system, is equivalent to 28 per cent of all the lamps connected in residences. When we compiled it, our idea was to take about thirty per cent of all the lamps connected in a residence.

"An objection raised by some to the lamps that are connected being used as a basis for arriving at the amount of current to be charged for at the higher rate, is that it prevents the installation of as many lamps as would otherwise be wired up. It does have that effect, and this may result in some loss in gross revenue; but our experience is that some check upon the installation of lamps is not altogether a bad thing. How often it happens that a party, arranging for the use of electricity, wires up his place profusely and after he gets his first bill realizes that he can not afford to use all his lamps, and then proceeds to vent his disappointment on the company, and, in disgust, not infrequently resorts to gas; or, if he continues to use electricity, cuts out part of his installation or uses such part only on special occasions—and special-occasion lamps mean a direct loss to the supplying company.'

Most of the members of the association are aware that the nickel-in-the-slot plan has invaded their art. Its most recent exponent is the prepayment meter introduced by the General Electric Company, the device being mechanically independent but electrically connected with a wattmeter. The prepayment device consists of a registering wheel disconnected from the handle, but which can be connected by the introduction into the receiving slot of a coin of proper denomination. When thus connected, the handle can be thrown so as to set the registering wheel of the prepayment mechanism forward one notch. If the circuit is open when a coin is deposited, the same motion of the handle which sets forward the



Prepayment Meter Register Wheel.

registering wheel closes the circuit switch contained within the case of the device. A portion of the registering wheel is visible through the glass in front of the cover, and plain figures on the rim of this wheel indicate the number of coins remaining to the credit of the depositor. When the first coin is deposited and the handle is moved closing the main switch, the figure "1" is brought to view. If a second coin be deposited before the current purchased with the first coin has been consumed, a second motion of the handle will bring the figure "2" into view. Twenty coins can be thus deposited consecutively, and, as the device is designed for dimes, prepayment can be made for $2.00 worth of electrical energy at one time, after which the slot is automatically closed and further prepayment can not be made until the value of one or more coins has been consumed.

Whenever 10 cents' worth of energy has been delivered through the meter, a small amount of current is momentarily sent through the electromagnetic mechanism of the prepayment device which turns the wheel back one number. This process continues until all the energy for which prepayment has been made has been delivered, and the customer can ascertain at any time how much energy can be obtained without further prepayment, by looking through the glass window of the device. When all the energy has been delivered, the registering wheel moves back to the first notch, and opens the switch, so that no more current can be obtained until further prepayment has been made. The indicating mechanism shows only the number of coins that stand to the credit of the depositor, but the dial of the meter may be consulted to determine what fractional part of the value to be cancelled next is credited. The dial of the meter always indicates the amount of energy delivered, and thus serves to check the indications of the prepayment device. The use of a dial both on the prepayment device and on the meter is an important feature, since it serves to show at once any discrepancy between the record of the meter dial and the number of coins deposited in the receiver. Every precaution has been taken to guard against cheating. A coin or washer larger than the coin for which the device is designed can not be introduced into the receiving slot, and a smaller one will not operate the device. A coin having a thread or wire attached passes through the mechanism and unlocks it, but the motion of the actuating handle cuts off the thread or wire so that the coin passes into the receiving box and can not be withdrawn, and the intended fraud is detected when the coin receptacle is opened. The coin receptacle is detachable and may be sealed at the company's office, and the collector entrusted with simply removing it and replacing it with an empty one. It would be interesting to get on record the experience of American managers in handling a prepayment system.

A type of demand meter taken up recently in this country is that of Mr. E. B. Schattner, of England. It is extremely simple in construction and consists essentially of a metallic frame pivoted at the centre, and carrying at one end a cylindrical iron core entering a solenoid, and at the other end a glass tube and scale. One part of the glass tube is bent to the arc of a circle concentric with the pivot of the frame. The tube contains a number of steel balls, and is filled with glycerine or oil. When current is passing, the core is sucked into the solenoid, and the frame is tilted to the right of its pivot. Any balls to the right of the highest point of the curved portion of the tube then slowly slide down and pass around the bend into the lower limb of the tube, where they remain. If at any time the frame is tilted by the solenoid still further to the right, one or more additional balls will be caused to descend into the tube. Consequently, when the meter is to be read, it is merely necessary to count the balls contained in this tube in order to determine the maximum current that flowed in the period since the meter was last set.

The tube is filled with oil or glycerine, the viscosity of which determines the speed at which a ball passes through the curved portion of the tube. A time element is thus introduced which prevents a ball descending into the lower limb if the higher current is merely momentary. According to the viscosity of the oil chosen, this leeway may vary from less than a minute to ten or more, and the time element may be made still larger by the use of glycerine as the fluid in the tube. Changes in the temperature of the fluid merely act to change this time element, in the selection of which there is considerable latitude. The balls, which are of steel and highly polished, are of the same type as those used in bicycle bearings.

The upper part of the sector carrying the tube is graduated, and in reading the sector is moved so that the end of the line of the balls remaining in the curved tube comes below a point projecting down from the case, when the maximum amperes that had passed in the circuit can be read off on the scale.

The tube is supported in the sector by three light wire clips. To reset, the tube is removed and tilted until all the balls are returned to the curved portion, when it is reclipped in the frame. The coils of the solenoid are so wound as to give as nearly as possible a uniform pull, and the range of the pull is such that one ball goes down for every quarter of an ampere in the middle of the scale, and for every half ampere on the remainder of the scale. To set the scale to zero, there is an adjustable weight on an arm projecting from the pivoted frame.

DEVELOPMENT OF NERNST LIGHTING

I am sure that few new departures in the lighting art have been watched with more interest than the introduction of the Nernst lamp, the general elements and features of which are now so well known to members as to need no comment. At the worst, we have in this lamp a valuable addition to our resources in subduing the whole domain of lighting; at the best, we have a device which has apparently advantages over some earlier methods in certain respects, and which rounds out the central-station efficiency. In view of the criticism leveled at the lamp from some quarters as to its economy, I have been surprised at its rapid advance, for there could be no more eloquent testimony as to its meeting a want than the fact that it has already, within little more than a year, been adopted by upwards of 1,000 central stations and isolated plants in this country.

The adoption by central stations of Nernst lamps is gradually being pursued in the same manner as with the incandescent lamp, that is, on the free-renewal system. The general result stated by Mr. Dunham of Hartford, Conn., who has 4,000 Nernst lamps, is that he can produce the same illumination at a general cost of less than one-half that of incandescent lamps, everything considered, on account of the lesser consumption of energy necessary with the same central-station equipment. Some of the larger installations for street lighting are at Hartford, Conn.; Unionville, Conn.; Rouse's Point, N. Y.; Annville and Sewickley, Pa.; Lincoln, Neb.; Madison, Wis., and Salt Lake City, Utah. In some cases it is the six-glower lamp that is being used for this purpose, comparing in energy and light with the ordinary 5.5-ampere inclosed-arc lamp. In other cases, it is the three-glower, and quite often the single-glower is used. The latter is especially well adapted, as it gives a candle-power of 50 with less than 100 watts' consumption.

Another installation is on the college grounds at the city of Mechanicsburg, Pa., which is operated by the Cumberland Light, Heat and Power Company. The lamp is being extensively used in shops and factories, halls, lobbies, office buildings and the like, such as the Riter-Conley Manufacturing Company, Leetsdale, Pa.; the Lunkenheimer Company, Cincinnati; the various shops of the Westinghouse interests, viz., Air Brake, Electric and Foundry; the Wellman-Seaver-Morgan Engineering Company; the Deering Division of the International Harvester Company; Deere and Company, Moline, Ill.; Williams, White and Company; the Atlas Tack Company, Fair Haven, Mass., and Swift and Company, Fort Worth, Texas. It is quite extensively used in the yards of Armour and Company, Swift and Company, and the Union Stock Yards at Chicago.

For office work and drafting it is being found specially well adapted on account of the uniformity of quality and the absolute steadiness of light. The drafting rooms of the Union Station of the Pennsylvania Railroad, at Pittsburgh, are completely equipped with Nernst lamps. The Farmers' Bank Building in the same city, which is the third largest structure of its kind in America, has two or three thousand lamps, and this plant has been illustrated and described in the technical press. The John Hartness Brown Department Store in Cleveland, O., which is the latest big store in that line, will be entirely equipped with Nernst lamps. Among special installations, there might be mentioned those of Barnum and Bailey and Ringling Brothers' Circus, where a special and unique traveling plant has been devised for the illumination of the vast marquee or arena tent in which performances are given.

Mr. Calvin W. Rice, second vice-president of the Nernst Lamp Company, states that when compared with the carbon incandescent lamp, the same light-giving power can replace clusters of incandescent lamps, and including the cost of maintenance, trimming, energy, etc., it can effect a saving of from 30 to 50 per cent. Of course, the question is a different one when we come to consider the demand for the smaller unit incandescent lamp of ordinary 16 candle-power.

OSMIUM INCANDESCENT LAMPS

There has been some inquiry during the year as to the osmium lamps, which, as members will remember, are of the Nernst type. So far as known, there are none at present in commercial use in this country. In the foreign journals, the following method of Deville and Debray for making the osmium wire is described. It is based upon the observation that if osmium vapors are sent through a tube of clay, the inner side of which is coated with an adherent layer of carbon, the tube being heated to incandescence, then osmium is deposited and replaces the carbon, *i. e.*, the carbon layer is changed into an osmium layer. By this method there is only a very small loss of osmium. For making osmium wires, carbon threads are placed in a case of clay; the air is driven out by means of nitrogen, and osmium oxide is introduced either in solid form or by means of a current of inert gas (nitrogen). The case is then heated to a high temperature, causing the carbon threads to change gradually into osmium threads, the change taking place in the direction from the outside to the centre. Very thin osmium threads can be made in this way, which is of importance, as it facilitates making lamps for the higher voltages. Another solution of the problem of making osmium filaments for normal voltage, and of such a rigidity that the incandescent filament does not change its form, is due to Dr. Auer von Welsbach, who uses the osmium wire in the form of a spiral of fine wire, consisting of windings of only a few millimeters. This spiral is supported and held in its form by means of a thread of mixtures of refractory oxides. The osmium wire is made by preparing a paste of osmium and certain other materials, and forcing it through a die. Single windings of this spiral of fine osmium wire may be in direct contact without diminishing the incandescence of this winding.

A test was reported last December from Germany of some osmium lamps, with globes like those of the ordinary carbon incandescent lamps. Nine osmium lamps of 37 volts and 25 candle-power were tried, three in series at 110 volts, for 300 hours; but the lamps were still in good condition after this time. The makers state the life to be 500 hours. During the tests the lamps were burning for 10 hours, and then disconnected for one hour, and so on. The different lamps gave about the same results; in one of them the candle-power decreased from 23 to 17.5, the current consumption in watts per candle increased from 1.53 to 1.97, while the average value of all tests for the 300 hours is 1.65 watts per candle. A comparative table gives the behavior of the ordinary carbon filament incandescent lamp, the Nernst lamp and the osmium lamp. The watts per candle are 3.20, 2.05 and 1.65 respectively. The first cost is nine, 50 and 125 cents respectively; if the price per kw-hour is 16 cents, the average total cost of a candle-hour is 0.0005, 0.00035 and 0.00045 cents respectively. This would indicate that the osmium lamp is economically superior to the ordinary carbon filament incandescent lamp, while it is still inferior to the Nernst lamp; but, of course, there are a number of other qualities and conditions to be taken into account. Mr. W. J. Hammer gives an excellent account of the general subject in his recent Franklin Institute lecture.

DIFFUSION OF LIGHT FROM ARC LAMPS

An interesting lecture at the last meeting of the Northwestern Electrical Association, by Mr. W. D. Ryan, of the General Electric Company, dealing with modern illumination, described the form of concentric-light diffuser that he has worked out for the improvement of arc lighting by cutting down the sharp contrasts of light and shadow and spreading the light equally in all directions, thus resembling in its functions the holophane globe as applied to the incandescent lamp. The apparatus consists of a metal diffuser attached to the lamp casing like an ordinary shade reflector. In place of the outer globe a screening shade is used which subdues the light directly under the lamp, while the upper portion of the shade is so shaped that much of the light strikes it beyond the critical angle and is then thrown to the diffuser and added to the direct rays, which naturally go upward. From the diffuser the rays are distributed, producing a white, steady, even light, pleasing and easy to the eyes, well adapted to the matching of colors, and independent of the nature or color of the ceiling. The diffuser is so arranged that the distribution of the light can be changed or "turned" without moving the lamp, as, for example, over looms or machine tools. Mr.

Ryan mentioned the case of Wanamaker's store where five arcs and 105 incandescents were in use in a certain section. They took out 100 of the incandescents and replaced them with five arcs with diffusers, using no more current but getting much better light, as well as a uniform light all of one color, instead of mixed lighting. He also instanced a shipyard with diffuser lights 60 feet apart and 150 feet high—something like the old tower lighting—where the effect was like day, and for the first time the new ships were so lighted that the men could work safely around them at night. He gave the following interesting table relating to the desirable allowance of .

WATTS* PER SQUARE FOOT FOR HIGH-CLASS ARC LIGHTING

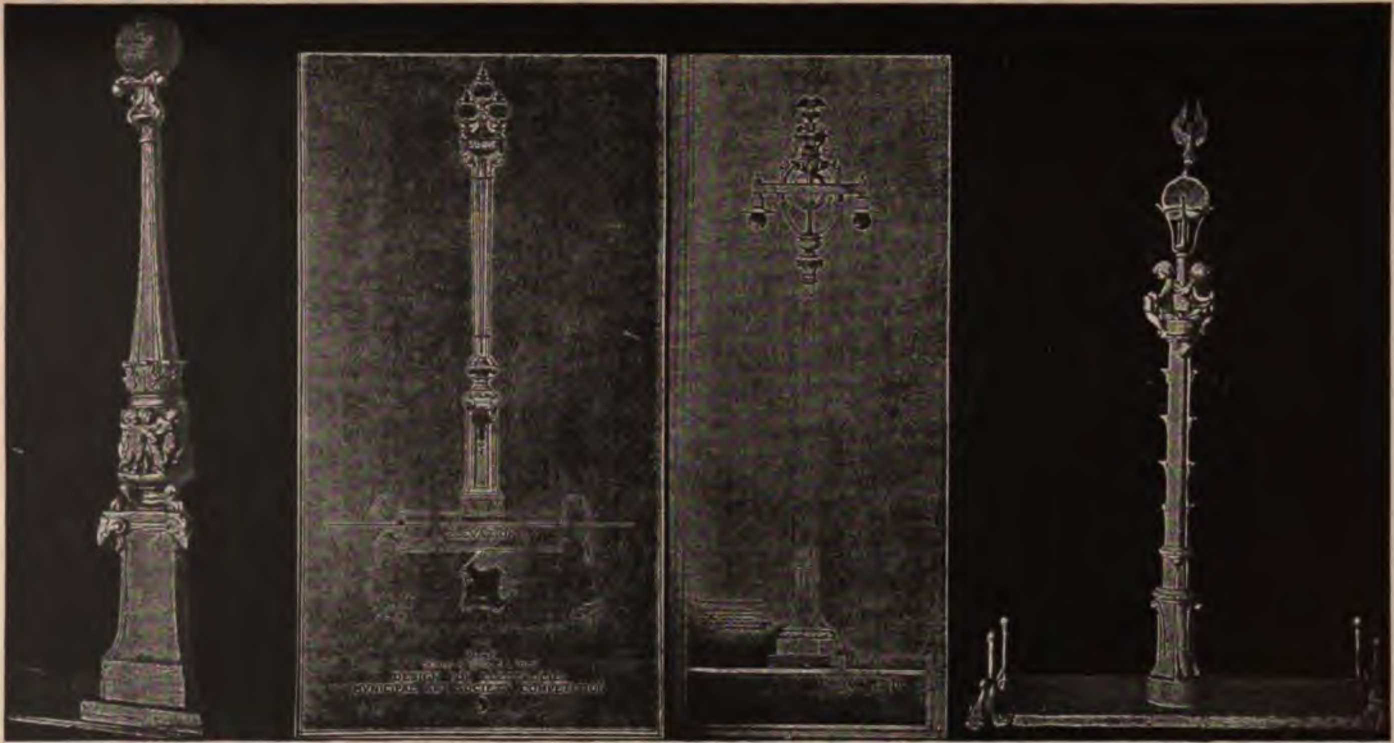
BUILDING	Average Conditions	Range of Variation
Machine shops, high roofs, electrically driven machinery, no belts	.75	.5 to 1
Machine shops, low roofs, belts and other obstructions.	1	.75 to 1.25
Hardware and shoe stores	.75	.5 to 1
Department stores, light material, bric-a-brac, etc	1	.75 to 1.25
Department stores, colored material	1.25	1 to 1.5
Mill lighting, plain white goods	1.1	.9 to 1.3
Mill lighting, colored goods, high looms	1.3	1.1 to 1.5
General office, no incandescents	1.5	1.25 to 1.75
Drafting rooms	1.75	1.5 to 2

* Energy based on watts at lamp terminals.

A STREET ELECTROLIER COMPETITION

The artistic improvement of the posts and standards employed to carry arc lamps, or clusters of incandescent lamps, has not escaped the consideration of this body, but so far as I am aware it has never made any direct efforts in the field of utilitarian astheticism. In the meantime, the Municipal Art Society of New York city organized last year a competition for the design of an electrolier to be combined with an "isle of safety," at the junction of Fifth avenue and west side of Twenty-third street, the electrolier when completed to be presented by the society to the city. The aim of this organization is, in this specific case, to obtain a simple and beautiful street fixture which may serve as an example for future work; to help to divide the traffic; to furnish a place of safety for foot passengers in passing the wide and crowded avenue, and to afford a place not only for the lamps, but for street signs. The competition was open to artists without distinction of age or sex, and the jury consisted of 15 members, including ten architects, painters and sculptors, and five laymen. The first prize was a commission to execute the necessary full-sized drawings and such modeled details as would be required for the execution of the proposed work, for a sum of $500. The second prize was $100, and the third prize, $50.

The regulations required that the designs submitted should not call for an expenditure of more than $1,500 for the final and complete execution of the electrolier. A space not larger than three feet by 20 feet was given as the size of the isle of safety, upon which the electrolier would be set up. Drawings and models submitted were required to be on the scale of 1.5 inches to the foot, and competitors could submit a drawing or a model, or both, the models being in wax or plaster. It was provided that competitive material should be sent in by June 14, and that the jury should render its decision within two weeks of that date. The competition thus undertaken by the society proved very successful, and no fewer than forty-five drawings and models were submitted. Four awards were made and I show these here. The successful competitor is required by the rules of the



Prize Designs in Electrolier Competition.

tion is brought out in Figure 2, which is a diagram of the circuits. Nos. 1, 2 and 3 are the circuits of a Y-wound three-phase generator, *i. e.*, the leads connecting to the corresponding electrodes 1, 2 and 3 in the static converter, and brought as shown to the neutral point of the Y-winding. The converter is started up by throwing for a short time on to the fourth electrode, not shown connected, the current from a small choke or kicking coil. A higher voltage than the normal running voltage is usually required to set the tube in operation, and this is given for a brief period as in the Hewitt mercury-vapor tubes. Soon after the converter gets going it attains a normal temperature at which it appears able to operate indefinitely. There is a drop of about fourteen volts across the tube, and the amount of heat to be dissipated is a direct function of that drop; so that the dimensions of a converter may be determined to take care of the heat due to any given maximum load. This drop in voltage between the upper and lower electrodes is approximately constant at all loads, but it is said that experiments indicate the possibility of cutting the 14 volts down to about six. The converter illustrated, and which I have myself seen in operation at various times, has been utilized at as high a pressure as 1,800 volts. This meant an efficiency of 99 per cent; while at 600 volts the efficiency would be about ninety-five per cent. The voltage delivered to the working circuit is constant, whatever the load; and it is believed that the present range up to 3,000 volts can be raised to 10,000.

It is obvious that with more than three phases, the working electromotive force would have less difference between its minimum and maximum values; in other words, it would more nearly approach a continuous current in character and smoothness. In watching the converter, the electric-valve action of the electrodes in suppressing a portion of the alternating-current wave is beautifully visible at a low frequency. The impulses from the several upper to the lower electrode can be followed and virtually counted by observation of the curious gyratory streams of mercury vapor. The mass of mercury forming the lower electrode has a motion of rotation the angular velocity of which varies with the frequency.

It would seem that whatever an ordinary rotary converter can do, this Hewitt static converter could do also; and it is to be borne in mind that a pulsatory current is regarded as best in storage-battery work. Incidentally, it is worthy of mention that a further advance of the principle has been made in its application to wireless telegraphy, a mercury-vapor tube taking the place of the spark-gap of the oscillating circuit at the transmitting end. The transformer secondary voltage may range between 10,000 and 20,000 volts. The fundamental advantage of this interrupter is the enormous speed of interruption that may be attained, and the absolute control of this speed. Moreover, by proper design and adjustment, any given rate of interruption can be secured. With the disruptive spark there is a limit to the efficient rate of interruption fixed by the time required for the condenser to clear itself, and this rate, as well as the total effect, is variable, owing to the mobility of the arc, the condition of the knobs with respect to polish, etc. This latter consideration does not apply to the mercury electrode surface, and the vacuum discharge is not subject to similar fluctuations. It follows that with this new type of interrupter it is possible to create and maintain continuously oscillations of an absolutely definite character, the great importance of which consideration with respect to wireless telegraphy is obvious.

CHEAPER PRODUCTION OF CURRENT

Much that has been said in preceding sections of this report deals with higher efficiency and economy of apparatus, and lower cost of current; so that ultimately we get back to the central station itself, and the desirability of improving methods and machinery there. The chief item of interest in central-station operation at the present time is the rapid advance of the steam turbine to the stage at which it becomes a formidable rival to the reciprocating steam engine. I am glad to note by the programme that this subject is to be duly taken up, so that much will not be needed from me in regard to it. A larger use is being made of our water powers, with cheap current as the result; and we are promised larger gas engines for dynamo driving run on producer gas; but steam remains the main dependence of our industry as a prime mover. Hence the encouragement afforded by economies due to improvements in condensing, by higher boiler pressures, by the use of superheated steam, by better steam piping, by automatic handling of coal and ashes. Incidental to this has come a virtual crisis in the creation of huge steam stations, so that we find competent, thoughtful men actually discussing the advisability of building smaller plants, or of dividing the big plant into a series of cellular plants, each of which is virtual unity. To such an extent has the drift of opinion gone, we must note that the American Institute of Electrical Engineers has been debating seriously the topic of the economical and safe limit to the size of central stations. There seems little doubt that while there is a tendency for several small stations to come together, at least under one management, there is on the part of the larger stations a tendency to stop in the recent popular plan of feeding out to huge sub-stations and to let those sub-stations become more generally autonomous for their respective areas, and themselves generators of the current there needed; although all tied with the common network.

Certainly, this is no time of finality in central-station design and construction, and, as a new element, the steam turbine may do much to readjust the conditions if it can support all that is claimed for it. Incidental to the discussion which will doubtless arise over the subject here, I am sure it will be of interest to members to see the accompanying comparative data, compiled by Mr. H. A. Lardner, for the Institute meeting just mentioned, as to steam turbines and reciprocating engines.

CURTIS VERTICAL TURBINES AND GENERATORS

Size	Height	Diameter	Floor Space	R.P.M.
500 kw	12′ 2″	7′ 8″	46.2 sq. ft.	1,800
1,500 "	16′ 10″	10′	78.5 "	900
3,000 "	22′	14′	154. "	600
5,000 "	27′	14′ 10″	175. "	500

WESTINGHOUSE-PARSONS HORIZONTAL TURBINES AND GENERATORS

Size	Height	Dimensions	Floor Space
400 kw	7′ 6″	19′ × 5′	95 sq. ft.
1,000 "	8′	43′ × 8′	344 "
5,500 "	15′	50′ × 12′	600 "

For comparison, the following is the floor space required by the vertical cross-compound condensing engines of a well-known maker. The figures include the space required for an alternating-current generator between the frames.

Size	Dimensions	Floor Space	R.P.M.
500 kw	15′ × 22′	330 sq. ft.	120
1,000 "	21′ × 24′	504 "	110
1,500 "	22′ × 28′	616 "	100
2,500 "	23′ × 32′	736 "	90
3,000 "	23′ × 34′	782 "	75

The height would in all sizes exceed that of a similar size of vertical turbine.

The steam consumption guaranteed for the above-mentioned Curtis turbines is also noted below. The figures are given in dry steam per kw-hour, and, for purposes of comparison with results per i.h.p., they have been reduced by assuming an efficiency for generator and turbine of 85.

Size	Pressure	Vacuum	Lbs. Steam per kw-hour Full Load	Lbs. Steam per kw-hour Half Load	Lbs. per I.H.P. Full Load
500	150	28	20½	23	13
1,500	150	28	20½	22	13
3.000	150	28	20½	21.5	13
5,000	150	28	20½	21	13

The general and hopeful view of the steam turbine was well summed up by that distinguished authority, Professor R. H. Thurston, when, in addressing recently the New York Electrical Society on the subject, he said: "The trend of progress and the promise for the immediate future is in the direction of further gain in economy of the machine by suppression of leakage and of friction of fluid within its casing by improved workmanship and by securing a better working substance by freeing it from water and also by utilizing the process of superheating to increase the thermodynamic range. This means, however, improvement at the boiler rather than at the engine, which latter is fitted in all its forms to employ superheated steam of any temperature that can be practically furnished from the steam generator. The trend of progress at the moment is also toward the application of specially designed and constructed turbines to special uses. It is probable that, gradually, forms will be adapted particularly to use in electric light and power 'plants;' others will find employment as marine engines and still others in other varieties of work. The regulation and the adjustment of speeds constitutes a problem, already satisfactorily solved in some cases, but which requires some further consideration in adaptation of satisfactory regulating mechanism to some special forms of turbine and to some special uses. The promise would seem at the moment to be the introduction very widely of a new type of prime mover which adapts itself in a peculiarly happy manner to purposes for which the common forms of steam engine are not likely to prove as perfectly satisfactory. The indications are that the supply of power by means of this motor will be made as low as with the best types of reciprocating engine and possibly lower, while its simplicity of plan and ease of construction would seem to insure freedom from liability to either accident or depreciation of value to any very important extent for long periods of time." As Professor Thurston remarked, the wastes of the turbine are apparently not far different in amount from those of the best work on the older types of steam engine, but are of a different kind and are peculiarly distributed. In his epochal paper before the American Philosophical Society on the Curtis turbine, Mr. W. L. R. Emmet, speaking of the 5,000-kw units built for the Chicago Edison Company, said that in these machines the variation of efficiency from half load to 50 per cent over load will not exceed three per cent.

Lest the future may seem to be all steam, I will quote from Mr. Butterworth's report on progress to the Ohio Gas Light Association, as to gas engines, as follows: "At the World's Fair in Paris in 1900, a 1,000-hp gas engine seemed a monster, but within the past two years sizes have been increased to as high as 4,000-hp, and the British Westinghouse Company is now building, at Manchester, England, 1,500-hp two-cylinder gas engines. America seems to be lagging behind Europe in the matter of the number of large gas engines in use, only 25 per cent being placed to our credit, although we have built as large as any that are in use thus far (4,000-hp), and one American firm has recently taken contracts to build 16 gas engines of 2,000-hp each. In Europe, the use of large gas engines with producer gas for operating factories has increased enormously within the past two years, one firm having made 32 engines averaging 1,390-hp, none of them less than 200-hp. The present tendency is toward the horizontal type of engine, but Mr. Herbert A. Humphrey, who is a student of this subject, predicts that the vertical type will finally prevail, especially for central-station work. Although most of these large engines are used, as stated, with producer gas, yet 280-hp gas engines are used in this country with ordinary illuminating gas. Mr. Humphrey says: 'The recent remarkable progress in large gas engines will undoubtedly continue until Sir Frederick Bramwell's prophecy of twenty-one years ago has been fulfilled and steam engines will only be found in museums.' "

STATE LABORATORIES

One of the most interesting and important questions affecting electric-light and power companies that has come up during the past year is that of State Electrical Laboratories. The plan took its origin in the State of New York, and in order that it may be understood, I append the text of the bill introduced in the Legislature:

The Governor, the State Comptroller, the State Engineer and Surveyor (Edward A. Bond), together with Charles P. Steinmetz and Harold Winthrop Buck, are hereby constituted and appointed a special commission to construct and equip a New York State Electrical Laboratory with such other duties as are hereinafter designated.

The commissioners shall select and acquire for the people of the State of New York upon such terms as they may approve a site for the location of a State Electrical Laboratory and proceed to construct suitable and proper buildings for the same, according to plans and specifications to be furnished by and under the supervision of the State Architect, and to equip, supply and furnish the same.

For acquiring the site and for the construction and equipment of such State Electrical Laboratory the sum of $275,000 is hereby appropriated, which sum shall be payable by the State Treasurer on the warrant of the Comptroller, out of moneys not otherwise appropriated, on bills audited by the said commissioners, or a majority of them. The said State Electrical Laboratory shall provide for the standardizing and calibrating of electrical meters and other electrical appliances and apparatus and for such independent investigations and experiments in electrical science as will furnish accurate and impartial data for the use and benefit of the people of the State of New York in the settlement of disputes arising from the development and use of electrical power; and for such further researches and experiments as will tend to increase knowledge of electrical power, and its application to serviceable ends.

The commissioners shall appoint a director of said electrical laboratory and fix his compensation and term of service. They shall further prepare a plan for management and control of said laboratory when completed, and shall have power to designate and appoint the members of a board of governors whose duty it shall be to direct and supervise the work of said laboratory, selecting and appointing all necessary employees, fixing their compensation and terms of service, prescribing their duties, formulating rules to govern work of the laboratory and determining fees of standardizing and calibrating, including the furnishing of certificates of conformation to the standard and compliance with the rules of the board, which certificate shall be *prima facie* evidence of the facts therein stated, and for such other work as may be properly subject to charge. All fees received by said laboratory shall be turned over to the State Treasurer to the credit of the general fund.

When completed and in operation, said State Electrical Laboratory shall receive and be open to and for the use of students in electrical science in any university, college or technical school which is or has been incorporated with the University of the State of New York under such rules and regulations as may from time to time be made by the board of governors of said laboratory, or by the director under their authority.

This sounds extremely well, and I doubt whether any electrical body or electrical engineer would place itself, or himself, in opposition to the expenditure of money that will aid the art and science. On the other hand, it may be pointed out that a national laboratory to do much of this work has already been established; that private institutions and colleges already afford such facilities, and that according to a report of an interview with him, Mr. Steinmetz has stated that the object is to prevent purchasers of electricity from being swindled. "The man who buys a pound of sugar," he said, "knows whether he is being cheated, but such is the limited knowledge which an ordinary person has of electricity that the ordinary purchaser of that commodity has to trust to Providence for his due." Conceding this, it is not known that the purchasers of gas, oil, milk, water or bread are similarly protected by special State laboratories; and it is very gravely doubted whether the members of this Association, or the manufacturers supplying them with apparatus, wish to see some forty or fifty inquisitorial bodies established over them, each with different standards, requirements and exactions. I have found electrical opinion in New York opposed to the scheme, as defined by its promoters, and as going far beyond any proper supervision such as is exercised by the usual boards of gas, electric-light and street-railway commissioners.

THOMAS COMMERFORD MARTIN, Committee.

THE PRESIDENT: If there is no discussion on the report, we will take up the next business, which is the report on office methods and accounting, by Mr. Walter M. Anthony, of Chicago.

Mr. Anthony read his report, as follows:

REPORT ON OFFICE METHODS AND ACCOUNTING

To the National Electric Light Association:

It might be a point of interest to ascertain the trend of thought which induced an ex-president of this association to make the recommendation eventuating in the preparation of this report. What prompted the initiative from so able a man? And is it out of place to add that the recommendation in itself is a substantial proof of his ability? Does not the principal solution lie in the fact that in order to keep up with the enlargement of his business horizon our friend has realized that he could do so only by knowing absolutely "where he was at"?

The rapid industrial development of modern times, and its complement of contemporaneous thought, absolutely precludes the personal attention of the general executive on the lines of the old-time superintendent, who was always "chief cook and bottle washer" of the whole establishment. Would even our worthy ex-president, progressive as he is, have felt the same necessity for making this recommendation several years ago, when he might have believed that his vision, at one glance, could comprehend the "Dan to Beersheba" of his whole responsibility, and bookkeeping, as such, was so useless a lad as to go barefoot ninety-nine one-hundredths of the time? And can, therefore, any of our present friends afford to remain standing to-day where our ex-president might have stood a decade since? Even ten years ago it was possible for wise men to harbor the thought and the hope that the day of capitalistic combination was but ephemeral, and that we should all shortly return to the old-fashioned, unrestrained, individualistic competition. Does any child of industry cherish such a belief to-day?

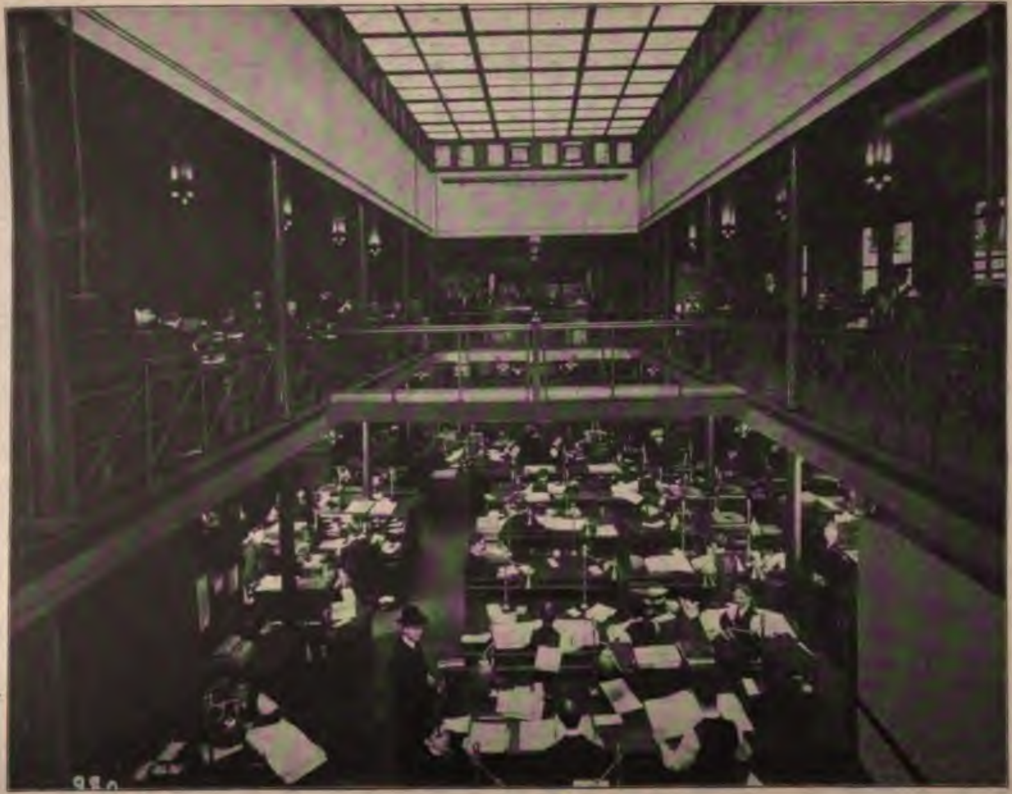
The question, therefore, which presents itself is this: Are we to do our present work on the lines of old-fashioned necessities, or are we willing to make a sincere effort to solve the problem in accordance with the needs of the time?

There are but few managers who can keep the details of even a small American business of to-day in their respective "hats" and but few enterprises that will long outlive such a policy, and the word "accounting" is beginning to be looked up a little more in the dictionary of industry, and the captains of industry are now realizing that the counting-room of the conservative banker is only an *open sesame* when the caller is backed up by a set of figures that do the talking. It is also refreshing to ascertain that stockholders, more or less, have a definition or two in their minds relating to accounting; and the words "system" and "method" are synonymous with, and handmaidens of, accounting, as without system and method, accounting is easily spelled with five letters—F-A-R-C-E.

How often in the past have we heard a chorus of representatives indulging in all sorts of mind-reading queries: "Our business is too small," says one.

"System and method are all very fine for you big fellows, but useless expense for us," pipes another.

"Oh, we have inched along without much book-



THE ACCOUNTING DEPARTMENT
CHICAGO EDISON COMPANY AND COMMONWEALTH ELECTRIC COMPANY

keeping so far, and guess we don't need any now," quotes a third, or "We have something else to do except bother with books and new-fangled notions," says a fourth.

"No nonsense or red-tape for me," quotes the mechanical or operating man, and so on, *ad infinitum.*

I can add right here, gentlemen, that most of the unfortunates who keep thinking or making these remarks, or similar ones, are simply playing the worm of yesterday to the early bird of to-day, although it is not the early riser, but he who gets the best sleep, who wins the worms, and it hardly pays never to move until you are shoved.

Perhaps there are many who fail to distinguish between the "bookkeeping" accounting of the past few decades and the "operating" accounting of the present. There is as much difference between the two as exists between the words "suspicion" and "intuition." You "suspicioned" that you might be right, in the first premise, and you "intuitioned" that you knew very well you were right, in the second.

The art of operating accounting consists in giving an air of distinction to insignificant but very important things in their inception; locking the door of knowledge *before* the horse of responsibility is gone. There are no unnecessary altitudes to take away the breath, and only a few shallow depths to alarm you. Simplicity and directness are its watchwords, but they begin, and end, with the material work performed, and not in the bookkeeper's imaginings, or on the superintendent's cuffs.

The pioneers of operating accounting have had, and are still having, an uphill row to hoe, and they will so continue to enjoy the same distinction until the employers themselves give ear to the still small voice of Costs, which is beginning to speak aloud in the land. The employers, as such, must have a better and deeper appreciation of the science and the imperative necessity of accounting, no matter whether the business be small or large, for the commercial god "Margin" (as between what *costs* value and *produces* value) will demand the attention of the employer whether he wills it or no—absolutely so, when the hill of prosperity begins to make its detour downwards.

Progression in accounting, if made, must be usually instituted and compelled by the employers. You can not look to many of the so-called "bookkeepers" to take it up, for the reason that employers, as a whole, have never made sufficient use of accounting and of the so-called bookkeepers to encourage the profession, as such, to take the initiative; therefore, as examples of non-progressiveness and bigotry, most bookkeepers, *per se*, are fearfully and wonderfully successful. As a class, they rub off about as little polish for future reflection from the operating man as it is possible to imagine. Their prehistoric traditions are too much for them. No wonder employers at times think so little of bookkeepers; but the employers are much to blame for this condition of affairs, by reason of the fact that in so many instances the accounting department is the waste-basket of the establishment, and many employers themselves have such slight appreciation for, or knowledge of, accounting as not to know the difference between the good and the bad.

The subject of operating accounting and its methods is comprehensive of so many wise essentials that it is only possible to touch upon a few. A circular letter was transmitted to each member of the association, asking for information, suggestions and devices, and setting forth a few important subjects in which all are inherently interested. Responses were not so numerous or so complete as was hoped for, and your reporter, therefore, must ask the indulgence of the association, since he has had to depend somewhat upon his own experience and environment, in order to complete in a sequence exhibit the task assigned.

In the letter referred to, the broad subject of "Receipts and Disbursements" was set forth, and under "Receipts" the topics of "Reading of Meters," "Billing of Current" and "Use of Customers' Ledgers" were presented.

In a small company, having but a limited number of customers, the reading of meters is more or less of a simple problem, and the last three or four days of each month are generally utilized in reading all meters, and the bills rendered ordinarily include the consumption of current for the calendar month specified; but as the business of the company grows, the necessity for a change in practice obtains, and the practice of a company having many customers is hereby set forth, as your reporter believes more can be gained from it to the advantage of the small and large company, respectively, than would be possible if only the practices of a small company were considered, although the best practices of companies approximating 1,000 customers are also set forth later on.

In the first place, in a large company the territory served is districted, the size or comprehensiveness of the districts being determined largely by local conditions, or the territories fed by particular plants, or the districts restricted to a certain number of customers, as determined by the desired size of customers' ledgers and the ability and capacity of certain employees.

The average maximum number of customers, and the average yearly growth of the business, determine somewhat the plan of action; and how often the same meters are to be read is also considered, as some meters are read weekly and bills rendered weekly, as the credit of a certain class of customers does not permit monthly readings as a safe practice, and, rather than demand deposits, based on monthly consumption, a system of weekly readings is instituted, with weekly billing and weekly collections, all with very excellent results financially.

The number of customers establishes the number of meter-reading days, and is the basis for the necessary complement of meter readers, although the extent of territory to be traversed contributes its factor also. The various factors having been ascertained, the question of reading meters resolves itself down to streets.

Each street is carefully considered and the routine systematically laid out and absolutely followed, so that the same customer has his or her meter read on practically the same corresponding working day of each month.

LOOSE-SHEET SYSTEM (RECEIPTS)

Each day and particular route has its own set of covers, and in this cover the loose-sheet meter cards (Form "A") are placed in exact accordance with the consecutive readings, as previously arranged. The readings are so distributed as to make the average work the same for each meter-reading day, whether the meters are read every day, or on certain days, whereby practically the same number of customers are read each meter-reading day by the same working force.

The Addressograph in Use

The loose-sheet or card system of meter forms provides for the necessary expansion or cut-off, as necessity demands. By referring to the meter cards (Form "A") it will be perceived that the form provides for reading the different classes of current supplies. The system, as a whole, is so elastic as to permit of all kinds of contingencies, and as growth must multiply, further additions can be made, and no change in the system itself is necessary.

The addressograph being set up in accordance with the routine of readings, the first printing of names and addresses on these meter cards is made by the addressograph; or some companies utilize the so-called billing typewriter machine for this class of work.

The addressograph, having these galleys set up corresponding with the routine of names and addresses appearing on any particular set of meter cards, prints the corresponding daily lists on the meter sheets (Form "B") and transmits same to the meter bureau on the day previous to the readings. The meter readings are transferred by hand to these meter sheets.

The addressograph also prints the corresponding billheads (Form "C") and the same are supplied to the billing bureau, and the addressograph at the same time also prints the corresponding envelopes, which are forwarded to the mailing bureau; and the addressograph can, if so desired, be so arranged as to print the customers' ledger sheets, as the names in the customer's ledgers absolutely correspond in consecutive order with the original routing, as provided for on the meter cards, the meter sheets, the billheads and the envelopes.

In the printing of names on the customers' ledger sheets, use can also be made of the Elliott and Hatch or Fisher billing typewriters, as these typewriting machines are particularly constructed with a view to doing all such kinds of work on books.

As soon as the meter card (Form "A") readings have been transferred to the meter sheets (Form "B") the meter sheets (Form "B") are transmitted to the billing bureau, where the billing instructions are kept on file on the basis of the card-bureau system. The dollars and cents portion of the meter sheets (Form "B") is inserted; the bills (Form "C"), previously supplied by the addressograph, are then filled out, as per information consecutively appearing on the meter sheets (Form "B"). The bills (Form "C") are then checked and forwarded to the mailing bureau, to be inserted in the envelopes, also previously consecutively prepared by the addressograph. The Elliott and Hatch and the Fisher billing typewriting machines are used quite extensively in connection with the billing of current, and where the bill is not too complicated, experience has proven the advisability of billing certain classes of current with these so-called "billing" typewriters.

As soon as the mailing bureau has received the bills, properly made out and checked, the envelopes containing said bills are then consecutively sealed by an electrical device called the "Thexton electric sealing machine," postage stamps are affixed and the mailing promptly attended to.

The billing bureau posts the totals of each meter sheet (Form "B") to the recapitulation balance sheet (Form "D"), and the meter sheets are then passed along to the corresponding customers' ledger clerk, who posts the results to the debit of each consecutive customer's account (Form "E"), each page of the customer's ledger (Form "E") being balanced as one customer, and the comptometer, but preferably the Burroughs arithmometer, is then used to draw off and compute the total of all the ledger sheets in the customers' ledger, said totals to balance with recapitulation sheet (Form "D").

Perhaps we may now note some of the advantages to be obtained by this scheme:

1. Elasticity, and no changes in methods necessary, no matter what the growth of the business may be.

2. The meter cards (Form "A") are the original source of entry, easy to carry and easy to refer to, but wisely do not contain any information as to discounts or billing, and valuable to refer to because said meter cards as a rule contain several previous months' readings, which are a guide to the meter reader in taking future readings off the dials; and these meter cards can also be used for showing all kinds of specific information to suit the necessity.

3. The meter sheet (Form "B") gives ample room for figuring and statistical information, permitting the classes of current billed to be kept separate, and each day's readings separate, so any class of current billed, or any day's readings, or any number of days' readings, can instantly be compared with any corresponding day or days of any month or period.

4. The addressograph can be used throughout the scheme, resulting in an infinite saving in time and labor. The billing typewriters can be used to great advantage on customers' ledgers and the billing of current. The arithmometer or comptometer can be used for ascertaining quick totals and balances. The Thexton electric sealing machine can be used for the quick sealing of envelopes.

5. The recapitulation balance sheet (Form "D")

The Comptometer in Use

not only furnishes a balance for each of the corresponding customers' ledgers, but also furnishes all kinds of comparative periodical information as to billing, and further statements or special reports are unnecessary (see Forms "F" and "G").

6. The ledgers are perpetual; no transferring of names is necessary except that an occasional sheet containing the names can be made over where too many changes have been instituted to make the original valuable except for file; a large number of accounts are included between comparatively thin covers, inasmuch us upward of 3,000 accounts can be handled by one bookkeeper. Your reporter believes this form of loose-sheet ledger embraces all the salient and efficient advantages of the card system, and as to rapidity, correctness and volume of work performed your reporter can attest, as your reporter uses both schemes in many different companies and in various kinds of enterprises. Your reporter believes each system is valuable, and that local conditions should govern the choice of adoption. Personal experience justifies your reporter, however, in pronouncing in favor of the loose-sheet form of ledger as represented by Form "E." It may be added that the Form "E" submitted herewith provides for weekly billing, or four or five readings per month. Where only one bill is rendered per month the form can be modified so as to include more accounts to the page or decrease the size of the sheet.

7. Every day's work balances with itself as it goes along, and as each day balances with itself, the month must necessarily do so. Each day's work being laid out, routine is soon established, and the acme of correctness possible; filing and self-indexing are made very simple, inasmuch as the indexing does much of its own work.

8. The Library Bureau card system is utilized in the meter and billing departments to tabulate all information concerning customers, addresses, meters, classes, character and size, and in the billing department to keep absolute record of all instructions coming from the contract department relating to discounts, special instructions for billing, and details connected with same.

CARD SYSTEM (RECEIPTS)

The following card system, as described, is used by a company supplying current to about 1,000 customers in two municipalities, modifications of which can possibly be made to suit the requirements of smaller or larger companies.

Meters—The meters are read monthly by regular employees of the company, two from the office and one from the meter department. The reading is started six days before the last of the month, so as to give ample time for making out of the bills and reading such meters as could not, for various reasons, be read on the regular days. On the first of the month the meter readers deliver the bills and collect from those customers who desire to pay, and also read such meters as still remain unread.

The meter-reading cards (Form W1) are ruled similar to the ledger cards (Form W2). The chief features to be observed in designing these cards are: space at the top for name, address and customer's number (these to be printed by the addressograph), location of meter, rate, number, size, volts, constant, date set, date removed, date read, index, and by whom read. The meter cards, when taken from the office, are carried in binders manufactured by the Library Bureau, but between reading times these cards are placed in special filing drawers, for convenience.

The impression prevails in some instances that it is better to have all the meters read direct in kilowatt-hours. Steps have been made by some companies in that direction by removing the unit hand from all but large-capacity meters, and on these the constant

THE ARITHMOMETER IN USE

has been changed, so that the meter will read in kilowatt-hours. It is claimed that this will reduce the labor of making out the bills considerably.

Billing—The utility of the card system is set forth by some companies. The customers are arranged in routes and numbered consecutively, 1, 2, 3, 4, etc., the ledger cards, meter-reading cards and bills being always arranged in the same order. Should a new customer be connected between 3 and 4, for instance, one company numbers this new customer as "3—10" or "3—50" or "3—75," according to the proximity of said customer to number 3 or 4, and much flexibility is thereby claimed in favor of the card system, one set of cards lasting four or five years without inconvenience. It seems to be the best practice of those using the card system to have the meter-reading cards and the ledger cards used together and expiring together.

In order to avoid errors, one company pursues the following method: Two persons work together; the bookkeeper calls the name of the customer and the index of the meter, at the same time writing the figures on the ledger. The clerk places the index on the bill (which has already had the name printed by the addressograph, and the previous reading and constant inserted). Both employees compute independently, the clerk calling off the kilowatt-hours and amount. By this method it is claimed that the chances for error are reduced to a minimum. The small company can modify this practice by placing the reading of meters, making out of bills and the collection of bills in the hands of one or two competent employees.

Ledgers—It is evident that many companies use the card-ledger system and claim to find it much more satisfactory than the book forms. This claim is particularly in evidence where the number of customers is comparatively small. A card is used for each customer, and some companies adopt different colored cards for different classes of current. For instance, buff — commercial incandescent, by meter; green—commercial arc; blue—motors; salmon—public street lights; white—commercial, by contract. After every twenty-fifth card there is placed an index card corresponding to pages in a book ledger, and in all additions the cards between these indexes are considered collectively.

With this system a book entitled "Summary Consumers' Ledger" (Form W3) is used, in which a permanent record is kept and footing of these so-called pages in which the sales and receipts are classified. On the left-hand page are the total additions from the ledger cards:

1 Balance from previous month
2 Sales—Kilowatt-hours
3 Sales—Billed
4 Receipts—Cash
5 Receipts—Discounts gained. Bills are rendered net, and the discount is treated more in the nature of a fine
6 Balances unpaid

To prove that the additions are correct, 1 and 3 must equal 4 and 6; also 4 and 5 must equal the total cash received, as shown in consumers' cash book.

On the right-hand page of the summary consumers' ledger, the sales of the different classes of current are classified.

Many companies believe that the card-ledger system shows the following advantages over the book form: There is no limit to its expansion; by arranging the cards in routes, the meter-reading cards and the ledger cards are always in the same order, which facilitates the making out of bills, and the meter cards and ledger cards can be so printed as to be used continuously for four or five years. If a customer disputes his bill you have his account for several years all together. If the company is a large one, several clerks can work on the ledger at the same time. On the back of the card there is room for explanations, special rebates, corrections, etc.

An adding machine is almost indispensable in the card-ledger system. Some companies use a "comptometer," which is very satisfactory, as it can be used on other computations, but for general work in the accounting department the Burroughs "arithmometer" is considered better, as it prints the figures, and the printed sheets can be used in checking by the bookkeeper and by any other party.

Some of the chief objections raised against the card system are its first cost and the fact that the cards are liable to get lost or destroyed to cover up theft. But the experience of the larger number of small companies shows that they have never lost a card, and they think that the value of the system is well worth its cost.

Where the meter cards and ledgers are arranged in routes an index is necessary. One company has its index card (Form W4) serve also as an application card, deposit record, and a record of the bad debts charged off. When a party makes application for current, he signs one of the cards, and by so doing acknowledges the receipt of a copy of the company's rules and regulations, which is given to him at the same time. On the back of this card the customer's name, address, etc., are printed with the addressograph, so that when filed the names will be uniform and the cards more easily found. The number of deposit, date received, amount, rate paid, amount paid, including interest, journal page, and any unpaid bills, are also shown. These cards are always kept on file, so that at any time when a former customer applies for current, it can be seen very readily whether or not he was in arrears.

CREDITS AND COLLECTIONS (RECEIPTS)

Credits and Collections—Prompt collections are a great essential, and a judicious, diplomatic insistence on the prompt payment of bills has a wonderful educational influence on all customers, inasmuch as they soon form the habit of paying promptly, and a close following up of all outstanding accounts materially reduces the percentage of slow payers; and it is a matter of absolute experience that a company stands 100 per cent better in the eyes of the community at large when it persists, in a quiet but well-determined and defined plan, in wisely collecting its accounts when due. Claims for adjustments, allowances and rebates can be so conducted and courteously handled as to make the customers of a public-utility company the strongest arm of the soliciting department and the best advertising agents the company possesses.

It is supremely wise to follow the principle of always giving the customers "the benefit of the doubt." You will lose temporarily—yes, but you build monuments for the future; and whatever is done in the way of allowances and rebates should be conceded quickly, and with the most cheerful spirit. A credit, collection and claim department, diplomatically officered, manned by a high grade of gentlemanly, well-groomed, intelligent collectors, can do more to keep business, get business and to create a kindly spirit in the minds of the public than perhaps any other agency which the company may possess, and it is particularly essential that the credit department on the one hand, and the contract or soliciting department on the other, work "hand in glove," with the most perfect harmony.

The lighting or power service of no customer should be ordered cut off for non-payment of bills until the soliciting agent, who possibly first obtained the business, or in whose district the customer resides or does business, has been duly notified of the fact of non-payment by the credit department; and said soliciting agent should be given the first opportunity to call on the customer and investigate all the details, inasmuch as the agent is perhaps enabled to modify the contract, or show the customer how he can better economize or reduce his bills, or how some possible increase in the efficiency of the service can be effected. A large number of possibilities eventuate, and the wise agent, at such a juncture, can also change himself, chameleon-like, into an extremely efficient collector; and the very fact that the customer obtains direct personal attention and consideration almost always results in the payment or prompt settlement of the disputed account, the retention of the customer, and a pleasant solution of what otherwise might have been a very unhappy affair; for a credit, claim and collection department not handled on these lines can cost a company more revenue in one year than a first-class soliciting force can obtain in new business in the same period. But it requires just as high-grade people to keep business on these lines as it does to get it in the first place, on the basis that it is perhaps more difficult to diplomatically placate a disturbed and irascible customer and keep him on your lines than it was to play the smooth part of the agent in obtaining the contract in the first place, for it is so easy for many agents to promise—and promise conscientiously, too—and so difficult for the credit and collection department of a company to make some of these promises good.

Perhaps the best practice is that in which the company allows the customer ten days from date of bill in which to pay the same and thereby save whatever discount obtains. Of course a large number of payments are made by check, mailed direct to the general offices; bills are also payable at certain specified places, not the offices of the company, as arranged for to convenience the public. Other bills are paid in cash over the counters of the general office, and the balance collected by collectors.

As a rule, a large proportion of bills is paid either by check sent to the office, or by cash paid over the counter at the office, and the Cummins perforating receipting stamp has been found a great labor-saver in the receipting of bills. This stamp not only receipts the bill by perforation, but perforates the stub as well, cuts off the stub, and all with one movement of the lever; and, still better, it receipts both bill and stub, and receipts and cuts off stubs of a large number of bills at the same time. This Cummins perforating stamp is also largely used by the cashier in cancelling all items held as petty cash, discharge time vouchers, and papers temporarily held by the cashier, thus preventing the possibility of some of these various items being presented subsequently, and paid twice.

The stubs of bills, showing the district, account number, customer's name, amount, etc., are all sorted, and as soon as sorted are posted to the particular district sub-cash book (Form "I") interested. A special district sub-cash book is kept for each district or corresponding ledger, or set of ledgers, and the totals of these various cash books are carried in one sum to the general cash book (Form "J"). By keeping a set of district sub-cash books corresponding with the ledgers, no time is wasted by any clerks in waiting for cash books in order to post promptly each day the cash received on said day (see Forms "H" and "K" for cash statements).

The Burroughs arithmometer is used to great advantage in the cashier's office. Duplicate deposit slips are most rapidly made, absolute correctness in totals being assured. Totals in cash books are quickly added and proven, and the machine has been found to be a very valuable adjunct as a labor-saving device throughout the general offices.

DISBURSEMENTS

The weak points of most accounting departments are, as a rule, more numerous and glaring in the expense or disbursement side of the business than in the handling of receipts or income, which weakness may easily be accounted for by reason of the fact that the customer demands or exacts a certain amount of attention, whether the vendor wills it or no, whereas the vendor is more willing to excuse lack of system or attention on the part of his customer, and this is almost equally true, if the customer and vendor be one and the same, on the basis that the customer's business must be attended to, but you can neglect, possibly, your own necessities.

Some of the points of weakness particularly in evidence lie in the making of purchases, the care of supplies, and the prompt handling of invoices, and the lack of attention in any or all of these directions precludes the possibility of costs and liabilities of the company appearing on the books at the earliest possible moment. Therefore, the books of the company can never be a true index of the financial condition of the property, and expenses and profits are

THE BILLING TYPEWRITER IN USE

not representative of the facts. There is altogether too great a temptation to let invoices hang around on desks and in drawers and out-of-sight places, everlastingly awaiting that convenient, leisurely period that never comes to a certain class of individuals. Consequently, in the end a stress of circumstances eventuates, and a large number of invoices are approved in a hurry, with characteristic looseness and no specific attention, and the accountant is forced to burn the midnight oil to post this avalanche of delayed work at a time of month when everything comes at once, and the financial executive is also left "up in the air," bracing himself up on the cheerful possibility that the worst is yet to come.

Only the consensus of best practice can be herewith set forth. It is impossible and impracticable to reproduce all the forms, and information concerning said forms, which your reporter may have received, and it has been thought more advisable to follow the best general practice and give the association the benefit of same. The value of any system depends altogether upon its usefulness to the managing officers, for if they make no use of the administrative policy to be gained by following up systematic teaching, a cash book is all that is necessary for such people.

That all purchases should be made through one source and by one individual, and that said individual should also be responsible for the storeroom, is generally conceded. Employees, as a whole, can not economically act as individual purchasing agents with any better result than can every employee pose around as if he were president.

The purchasing agent, or the representative acting as such, should have sufficient knowledge of the business to "sense" what the company requires, and to keep only such stock on hand as is absolutely necessary for the general average use. Supplies or necessities, not ordinarily kept in stock, can be ordered through the purchasing agent on the following system, which system is believed to include most of the valuable features pertaining to the subject.

PURCHASES AND INVOICES (DISBURSEMENTS)

Heads of departments are supplied with so-called department order books (Form "L"). These blanks are printed in manifold and bound in books of 100 consecutively numbered orders. The purchasing agent, immediately upon receiving this department order (Form "L"), approves same, if in line with the authorized policy laid down by the management, stamping the date and hour received, and subsequently inserting the number of his requisition order, which he issues on the vendor.

The purchasing agent then makes out on requisition order (Form "M") a requisition on the vendor for the supplies or necessities set forth on the corresponding department order above referred to. These requisition orders are in manifold also, although the carbon duplicate, which remains in the book for record, contains information as to the number of department order, the name of official to whom invoice is to be forwarded, and the classification number to which the material is to be charged, as this information is taken from the department order, the carbon paper being so arranged that the impress of this information does not appear on the original requisition transmitted to the vendor.

When the invoice is received, it is at once forwarded to the purchasing agent. If the invoice does not bear the original requisition order number, it is returned to the vendor, with notice that the invoice will not be honored until the requisition order number appears thereon. The purchasing agent compares all invoices received with the original requisition creating same, checking all specific details, which checking precludes any possibility of passing duplicate invoices at some future time; a very valuable precaution.

The invoice is then stamped with a special stamp, the use of which is seen as explanation follows: The purchasing agent inserts on the line provided for said stamp, the date received and the account number to which the invoice is to be a charge. The invoice is then listed on the daily disposition invoice sheet (Form "N"), which provides for name of vendor, date, amount, to whom forwarded, etc., and the invoice is then transmitted to the head of department making the original department order (Form "L").

If the head of department does not of himself have absolute previous knowledge of the arrival of the material, he passes said invoice to his proper subordinate, and said subordinate having knowledge of arrival of material approves the invoice, if correct, on the line provided for by the special rubber stamp. The head of department then compares invoice with the original department order, checks same as to details and approves the invoice, as provided for by stamp, and returns the same to the purchasing agent, who also approves.

The invoice is then forwarded to the accounting department for posting to the credit of the proper vendor's account, vouchering, etc.

A very large proportion of the invoices ordinarily cover purchases for stock. These invoices are listed on a special disposition invoice sheet (Form "N") and invoices are forwarded to the supply department or stock clerk or receiving clerk, as the case may be. The invoices are checked with the receiving books, and if found correct, are approved by the stock clerk, who returns same to the purchasing agent, who approves and forwards to the accounting department. If invoices are not promptly returned, the disposition invoice sheet quickly tells the tale, and the head of department is honored with the receipt of invoice tickler (Form "O"), and head of department is obliged to show cause why said invoices are being held or delayed; and if this invoice tickler does not bring the return of the approved invoice or a satisfactory explanation, the purchasing agent or clerk makes it his personal business to investigate ***instanter*** and is liable to interest some executive officer in this investigation, and the delinquent list shortly grows beautifully less; and, gentlemen, the "instanter" principle of handling department orders, requisitions on vendors and invoices, corrects more evils in the expense side of your business than all the other agencies combined. Prompt handling of invoices inaugurates reforms everywhere which otherwise would not have been thought of, resulting in great economy; the systematic and economical handling of materials; attention to details concerning supplies when said details are fresh in the minds of all concerned; instituting a check on purchasing to cover only absolute necessities; prevents duplication of bills, and thereby duplication of payments; reduces friction to a minimum, and helps materially to get your investment material into operating installation, thereby bringing quicker revenue returns; and finally results in the absolute knowledge that your books are the true index of your liabilities, and that your monthly costs include all items which properly belong to the specific month interested.

In some companies the purchasing agent's requisition orders (Form "M") are made in triplicate, the original going to the vendor, the duplicate going to the employee who is supposed to receive the material, and the triplicate remaining in the book for purchasing agent's record. The use of the original and triplicate

THE "CUMMINS" PERFORATING RECEIPTING STAMP IN USE covers much the same ground as explained above, but the duplicate, as used by the employee, is termed in some instances the "arrival notice," inasmuch as the employee receiving same is expected to check the material when it arrives with the items as listed on the duplicate or arrival notice, noting thereon, in some instances, the freight and cartage charges as well. This duplicate, or arrival notice, when checked by the proper employee, is then approved by the head of department and then returned to the purchasing agent, who attaches same to the invoice which he has held awaiting the arrival of the goods as per the return of the duplicate or arrival notice. The invoice, with the duplicate or arrival notice attached, is then forwarded to the accounting department. In this case, the invoice itself does not bear any evidences of official routine or handling. This system at first blush seems attractive, and with a company of the average size fills the necessity fairly well; and those adopting a similar scheme are to be congratulated, although a careful and wide experience, where the purchases are many, the material handled considerable, the invoices numerous, will justify the adoption of the first-mentioned system,— the disposition invoice sheet and making the invoice itself show its own history.

Employees, in the receiving of material (said employees having been previously supplied with an arrival notice), are too prone to check said material carelessly, and as the arrival notice already shows the list of material, this list and the material are too often taken for granted as corresponding, and nobody is the wiser, and many a so-called arrival notice is ostensibly checked and approved on faith—not really checked; but when the employee without previous knowledge is obliged to list the material he receives in a simple receiving book, and is obliged to check this receiving book personally with the head of department, who holds the arrival invoice, the constant espionage of the superior has its influence, as it must be constantly exercised—that is, the employer is constantly on the heels of the employee; and as a matter of record, the less number of papers for filing, the better, the original invoice showing on its face the entire history of the transaction, with the proper approvals, is believed to be the wiser policy, as one piece of paper—the invoice itself—tells the whole story.

The disposition invoice sheet, or other records, after having served the temporary purpose of "chief detectives," may be relegated to the waste-paper basket after a reasonable time has elapsed.

All systems require human conscientiousness of purpose, but that system which forecloses on this human conscientiousness the oftener, generally commends itself to the experienced operator, and the reputable employee always shortly afterward advocates this scheme, as it places responsibility, thereby avoiding the bane of business—friction.

ACCOUNTS PAYABLE AND VOUCHER SYSTEM (DISBURSEMENTS)

There are more voucher systems and forms of vouchers than there are enterprises, and as "simplicity" is our watchword, let us bring to the front the epitome of simplicity, permitting the greatest possibility of expansion, combined with the greatest scope of information, and this from an operating standpoint.

In dealing with purchases, we have brought the invoice, duly approved, into the accounting department fold. The moment invoices reach the accounting department they should be at once posted to the credit of the proper vendor's account in the accounts payable sub-ledger (Form "P"). The form submitted is fairly representative, being a loose-sheet ledger, with two sets of covers, one for active, the other for transferred accounts. It is generally conceded to-day that it is a wiser policy to keep a ledger account with each vendor, and not place your dependence altogether upon the voucher system or register of disbursements.

The accounts payable sub-ledger can be utilized to show many valuable points of information, such as original requisition number and the expense account number charged, saves many special statements, and much time in the hunting up of vouchers or records; and it is believed every company owes sufficient attention to a vendor to do him at least the courtesy of keeping a separate account with said vendor, which account can not be handled and checked with vendor's books so satisfactorily by depending altogether on the voucher, the invoice book, or the disbursements register. An accounts payable sub-ledger, properly handled, acts as a safeguard as to posting duplicate bills. It also gives quick information as to the amount of purchases made from any one vendor after any given period, and to what accounts the amount was chargeable. The loose-sheet system avoids the transferring of names, and by following a sequence of account numbers, the account of any one vendor is combined for any series of months or years. Invoices as posted are stamped "Posted" and filed in a vertical cabinet, a separate receptacle or filing place being reserved for each vendor.

At given periods, or at such times as suggest advantageous working, the vouchering begins. Special vouchers are, of course, issued from time to time as requirements demand, and handled on the spur of the moment, but 90 per cent of all vouchers can be styled "regular," and should be handled methodically.

The voucher clerk should, as a rule, keep the accounts payable sub-ledger, and with the vendor's accounts in this sub-ledger before him (all invoices to date having previously been posted), the voucher clerk simply copies the date of invoice, the amount of invoice, and the account to which it is a charge, on the face of the voucher (Form "Q"). If there are too many invoices for the face of the voucher, these invoices are posted to the voucher schedule (Form "R"), and the clerk simply writes on the face of the voucher (Form "Q") "For Bills Rendered as per Schedule Attached." Ninety per cent of the vouchering is thus done direct from the accounts payable sub-ledger.

When the vouchering, or any part of it, is completed, the auditor takes the voucher and consecutively removes the respective invoices concerning same, as wanted, from the vertical file interested, and audits each invoice, date, amount of charge, and certifies as to the correctness with his signature, thereby proving the voucher clerk's work and all the accounts in the accounts payable sub-ledger. The invoices are at the same time stamped with the voucher number and placed back in their respective places in the vertical file. The vouchers are then entered in the voucher record or register of disbursements, as explained further on.

At such time as practice suggests, checks are drawn, and vouchers with checks attached are passed along to the proper executives for signature; the vouchers and voucher schedules, being printed in copying ink, are copied in a special tissue impression book (to provide for reproduction in case of loss); the pages of said book corresponding with the number of the voucher saves all indexing. The vouchers, with checks, together with printed return envelopes enclosed, are then mailed to the vendor.

THE THEXTON SEALING MACHINE IN USE

As soon as the voucher, duly received by the vendor, is receipted and returned, the invoices interesting said voucher are removed from the vertical file and are at once firmly fastened together, with the cancelled check, and the voucher is then filed flat, as per consecutive numbering, in special voucher box in the vault. Inasmuch as the accounts payable subledger is so explicit in itself, it is not often necessary to refer to the invoices and vouchers for subsequent information. Therefore, the voucher files remain in generally better condition.

The consensus of opinion points to the advisability of so printing the voucher (Form "Q") that the face of the voucher shall provide for all information or writing—the listing, the distribution charge, the signatures, the receipting—and when any considerable amount of distribution (such as pay-rolls) is necessary, a special distribution schedule (Form "S") can be used in connection with the voucher.

It certainly is inconvenience personified to be obliged to turn any form at all angles, either to write thereupon or to attach signatures, and the less the back of any form is used, the better. The face should show everything at a glance. Executives do not desire to figuratively stand on their heads, or turn several ways at once, either to sign or to observe necessary details, and if the accounting people would only forget themselves more and study the *tempus fugit* motto from the viewpoint of the operating official, accounting would sooner become a fine art. The average operating official wants to read while he runs, and he is not pleased to perform unnecessary "stunts," or twist himself inside out in order to observe what should be presented to him as plain, unvarnished facts.

To gain the respect and co-operation of the operating and executive officials, study to furnish them with the plain *table d'hôte* of horse-sense all on the face side, and, if you please, keep the hieroglyphics of the *à la carte* double-faced plan in the accounting department; and your reporter, gentlemen, is basing this entire report from the standpoint of the operating and executive official. They are the people the stockholders look to to run the business—not the bookkeepers—and your reporter would rather please an aggregation of operating or executive officials, and give them what they want, than humor the whole tribe of bookkeepers on points of this kind—and your reporter is known to have a very soft spot in his anatomy for bookkeepers, too.

The bookkeeper, who will "fall off his perch" once in a while and take a peek at things as they are through the spectacles of the operating official, will have his eyes opened to his own prospective advantage. This, perhaps, is a little digression, but it is wise to stir the animals up now and then, as it is depressing to stand on one leg too long.

THE VOUCHER RECORD (REGISTER OF DISBURSEMENTS)

The form of voucher record, or register of disbursements (Form "T"), submitted herewith, was selected because it embraced the widest scope of business activity, and the requirements of the street railway, the lighting company, the gas company, the express company, the heating company and water-power company are all included in one form or system, the classification utilized being the standard system of street-railway accounting, and the uniform classification of electric-lighting accounting, and special local classification in regard to gas, express, hot-water heating or water-supplying companies; so the scheme is not a lonesome one, as being confined or limited to any one line of business.

As soon as the invoices have been checked and the voucher approved by the disbursement auditor or clerk, the vouchers are entered in the register of disbursements in numerical sequence, and the totals are also posted to the special classification number in the abstract of expenditures.

Now, gentlemen, the register of disbursements, and its twin brother, the abstract of expenditures (Form "U"), are very valuable adjuncts to a properly conducted accounting department, and no one can harshly criticize a consummation of methods that will embrace within itself an accounts payable sub-ledger system, a vouchering system, and a distribution system of expenditures, such as will take microscopic care of the expenditures of millions of money per annum for the construction and operation of a formidable array of all kinds of stations and substations, as interesting a lighting business, a merchandising business, a contracting business and a repair-shop business, and have all this disbursement work performed at the minimum of expense and the maximum of efficiency; and your reporter is advised of instances where a street railway, lighting company, water company, gas company—combined enterprises of no mean magnitude—are being most successfully and similarly served; and when you consider this minimum of expense, and this maximum result of efficiency, and that the operating officials are the happiest individuals in the bunch, it is generally believed that a thoroughly practical system has perhaps been evolved—a system that is just as simple, and proportionately inexpensive and practical, for the little fellow as for the big fellow, the only difference being that the "big fellow" fills up a few more pages.

The register of disbursements (Form "T") explains itself, as it simply provides the skeleton of consecutive general ledger headings or classification groupings of all expenditure accounts, such groupings as would naturally appear on the monthly statement or balance sheet. But the abstract of expenditures (Form "U") supplies the detail of each classified account, a certain group of consecutively classified accounts proving with the one or skeleton column in the register of disbursements representing the same identical group.

The great saving of time and the efficacy of the scheme lie largely in the remarkable elasticity of the abstract of expenditures, as the distribution of expenses for any number of stations, or any number of varied enterprises, is embodied in the smallest possible space; the stations may multiply indefinitely, or the enterprises breed, and all that is necessary is to add the respective number of self-indexing sheets, and one small book on one small desk, and one intelligent clerk, will take care of an amount of classified distribution wholly impossible to conceive of if the actuality has not been observed.

The abstract of expenditures (Form "U") is a loose-sheet affair, with a set of active covers and a set of corresponding transfer or "dead" covers.

It will be noticed that each sheet has a set of numbers on the edge. Each set of numbers corresponds with a grouping of classified accounts, as set forth in the skeleton of the register of disbursements. The clerk simply takes a single sheet, and with a pair of scissors cuts out all the numbers on the sheet except the top number. On the second sheet he cuts out all the numbers except the two top numbers. On the third sheet he cuts out all except the three top numbers and so on until he reaches the last number, the lowest number on each sheet thus cut being the index number concerned.

When you place a specific group of these sheets together in sequence, you have absolutely a self-indexing arrangement, combining and grouping a specific set of expense-account numbers, indexing, too, on both sides, and as one sheet is filled up the clerk simply cuts another sheet, exactly like it, and places it directly after its counterpart—and so on, *ad infinitum;* and when any number of index sheets, bearing the same index number, are filled up, these sheets, or any part of them, are removed to the transfer file. There is also a recapitulation sheet which is used to assemble the totals of each specific grouping, this sheet proving the respective skeleton amount in the register of disbursements (see Form "V" for comparative monthly statements).

And what does this signify? It means that in one small book you have obtained an amount of classification covering the scope of all your classified accounts, no matter how many stations you have, or how many enterprises you include. You have the opportunity of comparing the showing of any one month with the showing of the same account for any number of previous months, as all the account number twos are together, all the account number threes are together—and so on indefinitely. You can take any of the accounts temporarily out of the abstract and confer as to the showing thereon with any head of department, without said head of department knowing anything about any other account. Any number of clerks, in the stress of circumstances, can be utilized in collecting or tabulating expenditure information at any one time, as the book can be split up in sections; and, generally, you are dealing with the original tabulation taken direct from the voucher and the invoice, and therefore an untold amount of special statement work, or typewriter tabulated copies, is avoided, as heads of departments can see the original facts for themselves and on these same sheets.

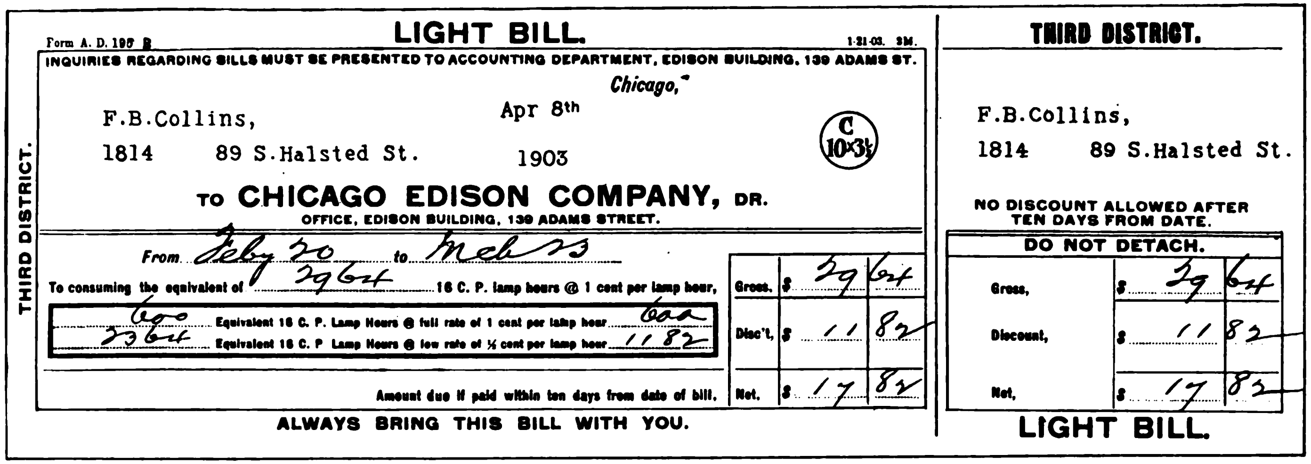
In conclusion, your reporter wishes to thank the members who responded to the circular letter, and to whose assistance much of the value of this report can be ascribed.

Even after repeated boiling down in its preparation, the length of this report, with the forms submitted, is open to criticism, and the time taken in presenting must have taxed the patience and good nature of the association, and your reporter therefore thanks the association for its courtesy and attention.

All of which is respectfully submitted.

. WALTER M. ANTHONY, *Reporter.*

K



Form A. D. 195 B

LIGHT BILL.

1-21-03. 3M.

THIRD DISTRICT.

INQUIRIES REGARDING BILLS MUST BE PRESENTED TO ACCOUNTING DEPARTMENT, EDISON BUILDING, 139 ADAMS ST.

Chicago, Apr 8th 1903

F.B.Collins,
1814 89 S.Halsted St.

C 10x3½

TO **CHICAGO EDISON COMPANY,** DR.

OFFICE, EDISON BUILDING, 139 ADAMS STREET.

From Feby 20 to Mch 23

To consuming the equivalent of 2964 16 C. P. lamp hours @ 1 cent per lamp hour,

600 Equivalent 16 C. P. Lamp Hours @ full rate of 1 cent per lamp hour 6 00

2364 Equivalent 16 C. P Lamp Hours @ low rate of ½ cent per lamp hour 11 82

Amount due if paid within ten days from date of bill.

Gross,	$ 29	64
Disc't,	$ 11	82
Net,	$ 17	82

ALWAYS BRING THIS BILL WITH YOU.

THIRD DISTRICT.

F.B.Collins,
1814 89 S.Halsted St.

NO DISCOUNT ALLOWED AFTER TEN DAYS FROM DATE.

DO NOT DETACH.

Gross,	$ 29	64
Discount,	$ 11	82
Net,	$ 17	82

LIGHT BILL.

BILL-HEAD—FORM C

BOUND IN TABLETS—A different bill-head used for each class of current

Form A D 218. 500 8 9 02

DISTRICT NO. ....

Comparative Statement "Bills Rendered" Month of .... 190.. and 190..

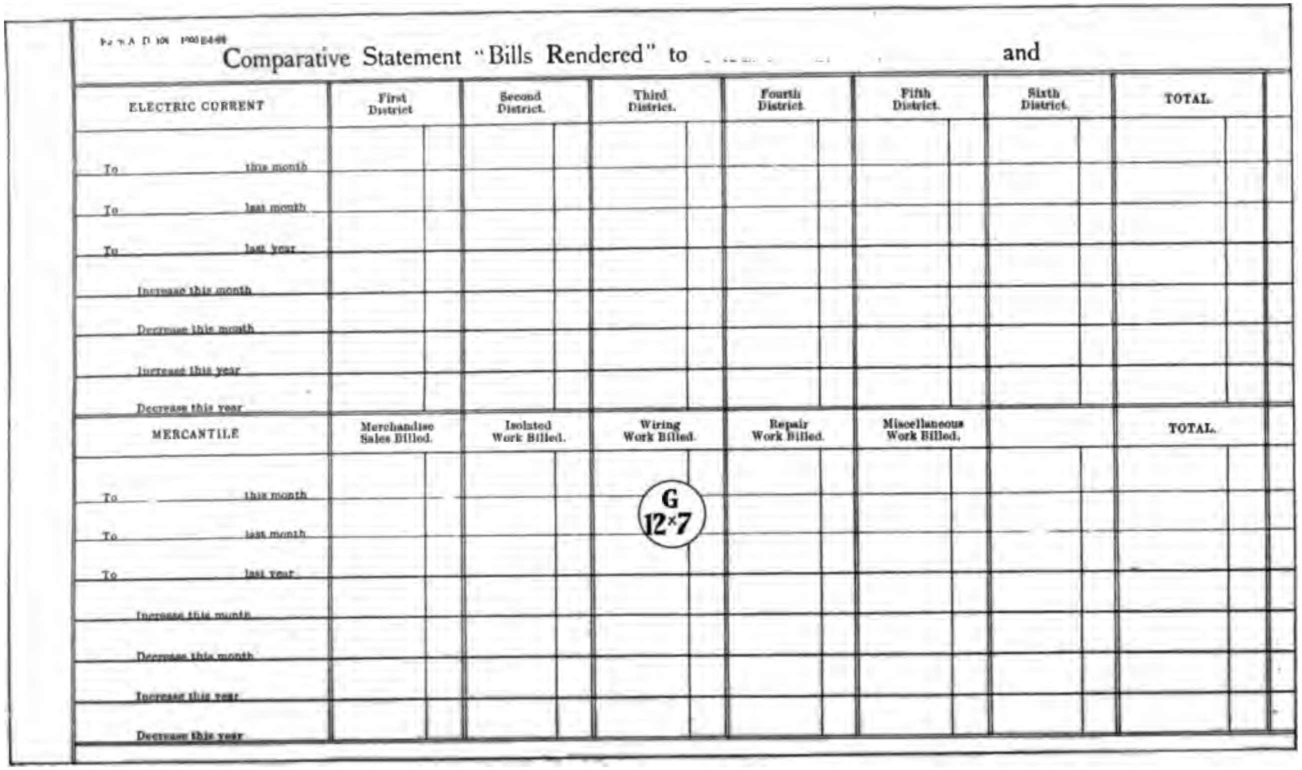
ELECTRIC CURRENT.	L. T. INCANDESCENT AND METER ARC	ALT. INCANDESCENT AND METER ARC	POWER			LAKE STREET ELEVATED R. R.
			Low Tension	500 Volt	Alternating	
190						
190						
Increase this year						
Decrease this year						

	ARC LIGHT					TOTAL FOR MONTH
	L. T. Contract	Series	Alternating			
190						
190						
Increase this year						
Decrease this year						

F 11¾×5¾

WEEKLY REPORT—FORM F
(Different classes of current sold)

BOUND IN TABLETS—Used weekly, monthly or at desired periods. Figures to be taken from totals obtained from the Recapitulation Sheet (Form D)



[illegible]

Comparative Statement "Bills Rendered" to and

ELECTRIC CURRENT	First District	Second District.	Third District.	Fourth District	Fifth District.	Sixth District.	TOTAL.
To this month							
To last month							
To last year							
Increase this month							
Decrease this month							
Increase this year							
Decrease this year							
MERCANTILE	Merchandise Sales Billed.	Isolated Work Billed.	Wiring Work Billed.	Repair Work Billed.	Miscellaneous Work Billed.		TOTAL.
To this month							
To last month							
To last year							
Increase this month							
Decrease this month							
Increase this year							
Decrease this year							

G 12×7

Weekly Report—Form G
(Billing to Customers)

Bound in Tablets—Used weekly, monthly, or at desired periods. Figures to be taken from totals obtained from the Recapitulation Sheet (Form D)

C. E. Co. Form A. D. 108. [illegible]

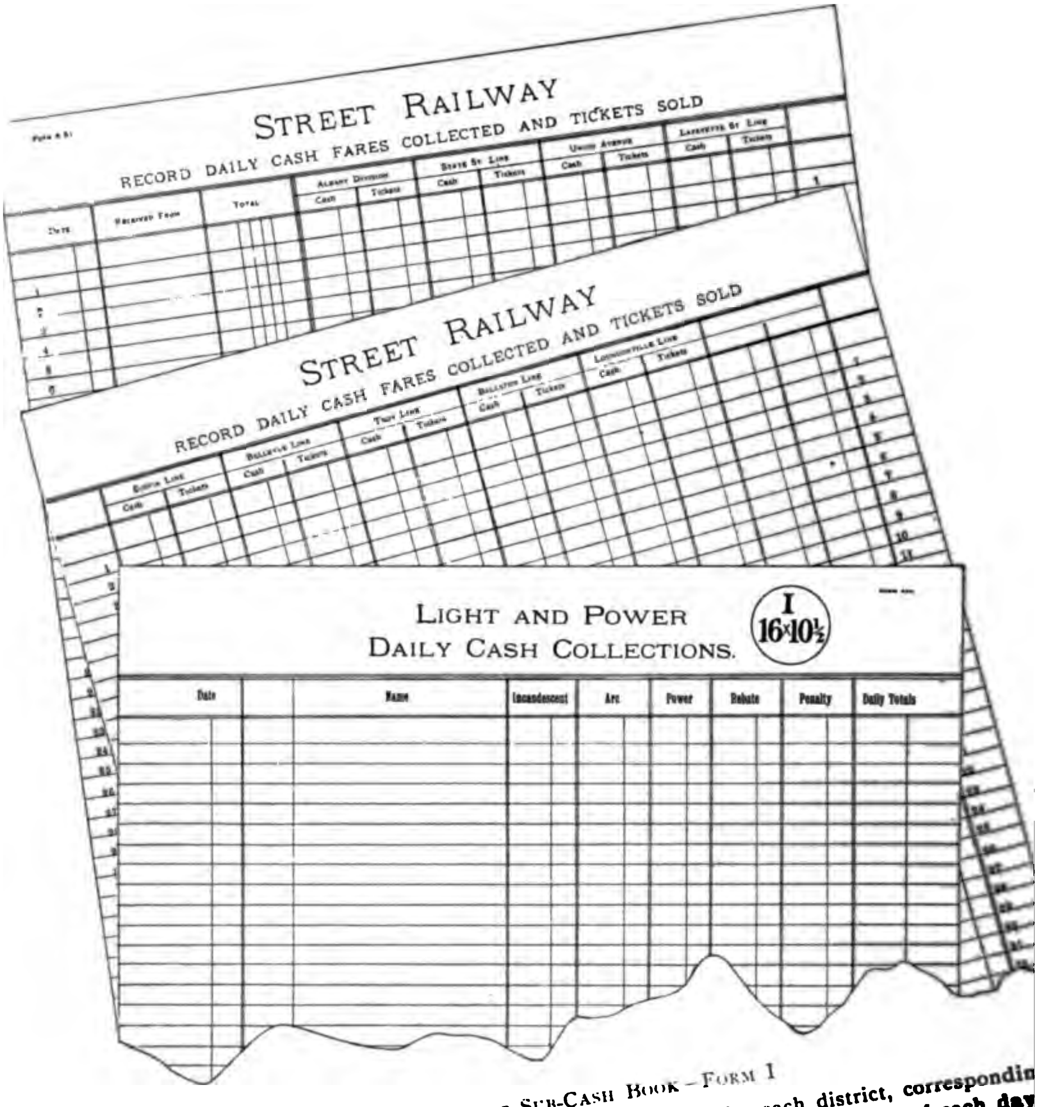
Comparative Statement "Collections" made to .... 190.

COLLECTIONS.	Mercantile.	First District.	Second District.	Third District.	Fourth District	District.	Sixth District	District.	TOTAL.
To this month									
To last month									
Increase this month									
Decrease this month									
Net Increase									
Net Decrease									

H 11×5½

WEEKLY CASH REPORT—FORM H

BOUND IN TABLETS—Used weekly, monthly or at desired periods. Figures to be taken from totals obtained from General Cash Book (Form J)



STREET RAILWAY

RECORD DAILY CASH FARES COLLECTED AND TICKETS SOLD

Date	Received From	Total	Albany Division		State St. Line		Union Avenue		Lafayette St. Line	
			Cash	Tickets	Cash	Tickets	Cash	Tickets	Cash	Tickets

STREET RAILWAY

RECORD DAILY CASH FARES COLLECTED AND TICKETS SOLD

[illegible] Line		Bellevue Line		Troy Line		Ballston Line		Loudonville Line	
Cash	Tickets	Cash	Tickets	Cash	Tickets	Cash	Tickets	Cash	Tickets

LIGHT AND POWER
DAILY CASH COLLECTIONS.

I
16x10½

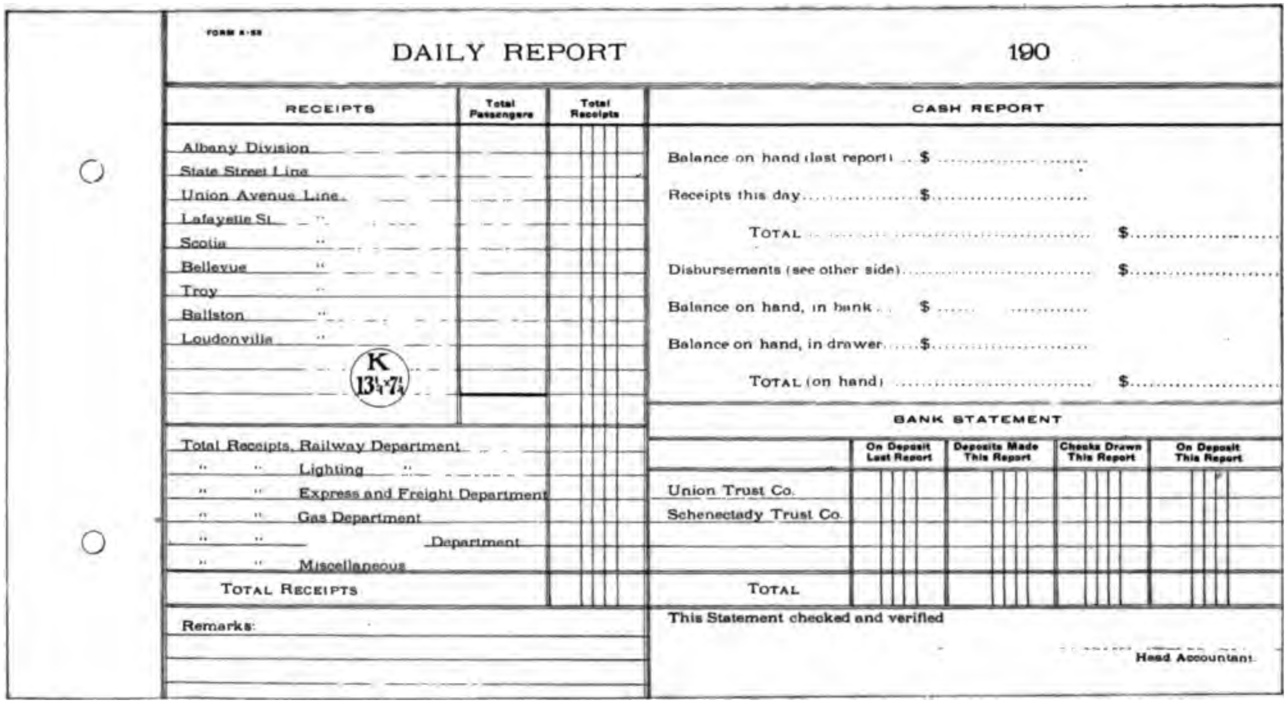
Date		Name	Incandescent	Arc	Power	Rebate	Penalty	Daily Totals

DISTRICT SUB-CASH BOOK – FORM I

BOUND BOOK—A separate sub-cash book being used for each district, correspondin and posted in detail to Customers' Ledger for same district. Totals of each day collections posted to General Cash (Form J), and balancing with correspondi Customers' Ledger

THE NEW YORK
PUBLIC LIBRARY

ASTOR, LENOX AND
TILDEN FOUNDATIONS



FORM K-58

DAILY REPORT 190

RECEIPTS	Total Passengers	Total Receipts
Albany Division		
State Street Line		
Union Avenue Line		
Lafayette St. "		
Scotia "		
Bellevue "		
Troy "		
Ballston "		
Loudonville "		
Total Receipts, Railway Department		
" " Lighting "		
" " Express and Freight Department		
" " Gas Department		
" " Department		
" " Miscellaneous		
TOTAL RECEIPTS		

Remarks:

K
13¼×7¼

CASH REPORT

Balance on hand (last report) ... $ ....

Receipts this day.................. $ ....

TOTAL .... $ ....

Disbursements (see other side) .... $ ....

Balance on hand, in bank ... $ ....

Balance on hand, in drawer ...... $ ....

TOTAL (on hand) .... $ ....

BANK STATEMENT

	On Deposit Last Report	Deposits Made This Report	Checks Drawn This Report	On Deposit This Report
Union Trust Co.				
Schenectady Trust Co.				
TOTAL				

This Statement checked and verified

Head Accountant

DAILY CASH REPORT—FORM K

BOUND IN TABLETS—Used daily, figures taken from daily totals obtained from General Cash Book (Form J). Disbursements for the date indicated, if desired, can be posted in such detail as desired on back of this Daily Cash Report

FORM 11. Joliet, ... 190 . . . Order No. . . . .

TO THE PURCHASING AGENT:

Please order the following articles for the Company, to be charged to account specified.

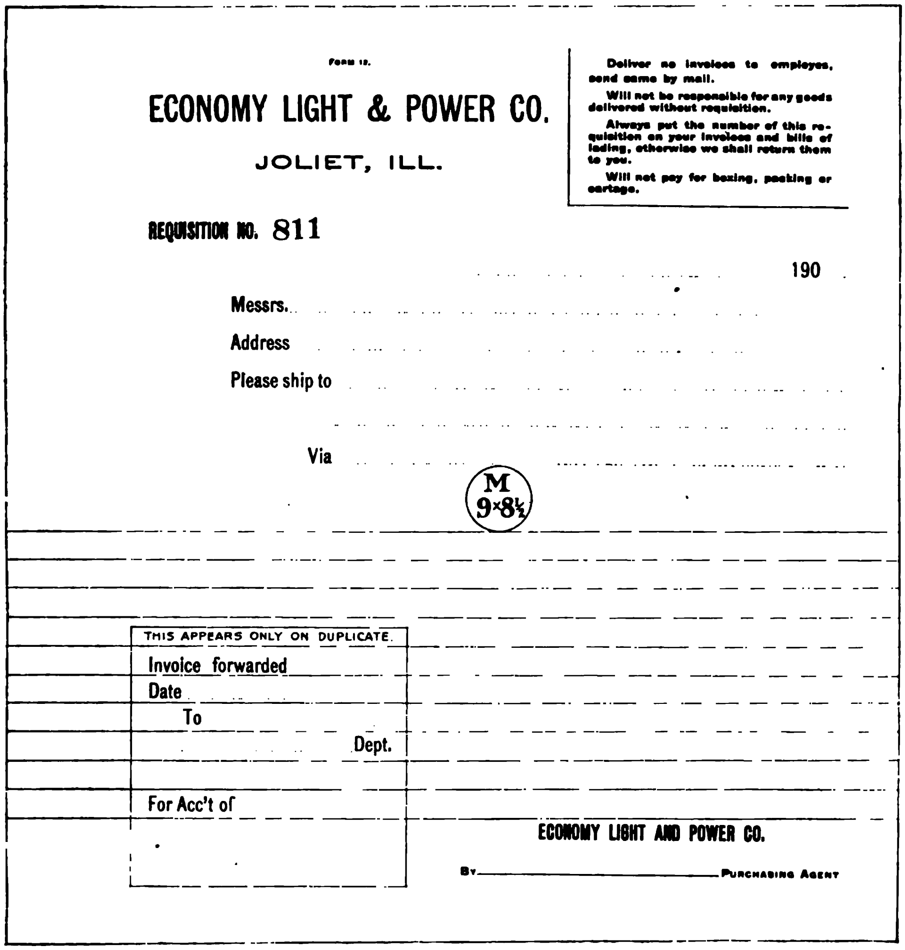
QUANTITY	ARTICLES.	CHARGE TO
○		
	L 9½×6	
○		

SIGNED ....

APPROVED ....
HEAD OF DEPARTMENT

DEPARTMENT ORDER ON PURCHASING AGENT—FORM L

BOUND BOOK—Manifold, original and duplicate. One hundred consecutively numbered orders in each book



Form 12.

ECONOMY LIGHT & POWER CO.

JOLIET, ILL.

Deliver no invoices to employes, send same by mail.

Will not be responsible for any goods delivered without requisition.

Always put the number of this requisition on your invoices and bills of lading, otherwise we shall return them to you.

Will not pay for boxing, packing or cartage.

REQUISITION NO. 811

190 .

Messrs.

Address

Please ship to

Via

M

9×8½

THIS APPEARS ONLY ON DUPLICATE.

Invoice forwarded

Date

To

Dept.

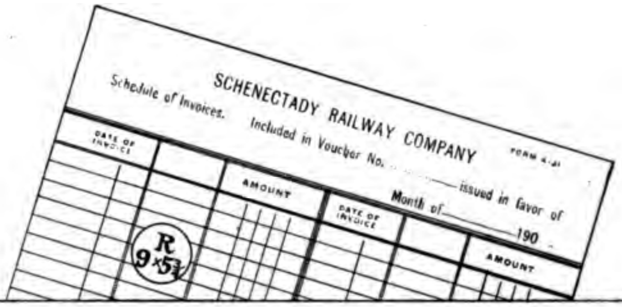
For Acc't of

ECONOMY LIGHT AND POWER CO.

By ______________ Purchasing Agent

Requisition Order on Vendors—Form M

Bound Book—Manifold, original and duplicate. One hundred consecutively numbered requisitions in each book



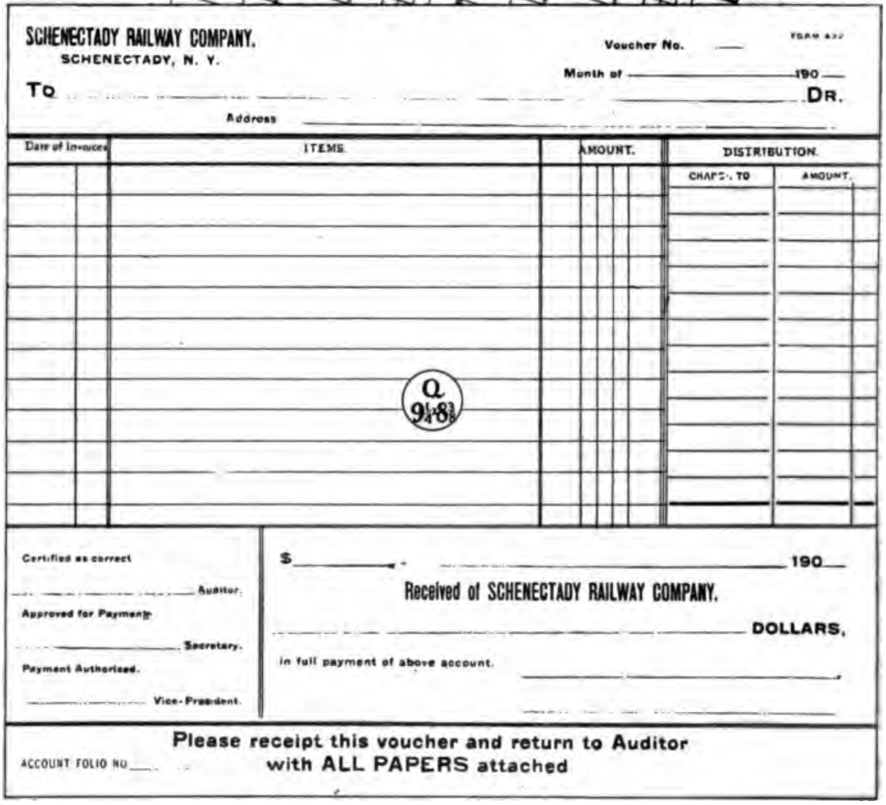
SCHENECTADY RAILWAY COMPANY

Schedule of Invoices. Included in Voucher No.______issued in favor of

Month of______190_

DATE OF INVOICE		AMOUNT	DATE OF INVOICE		AMOUNT

R 9×5¾



SCHENECTADY RAILWAY COMPANY.
SCHENECTADY, N. Y.

Voucher No. ____

Month of ______190__

TO ______ DR.

Address ______

Date of Invoices	ITEMS	AMOUNT.	DISTRIBUTION.	
			CHARGE TO	AMOUNT.

Q 9¼×8⅜

Certified as correct

______Auditor.

Approved for Payment.

______Secretary.

Payment Authorized.

______Vice-President.

$______ ______190__

Received of SCHENECTADY RAILWAY COMPANY.

______DOLLARS,

in full payment of above account.

______

ACCOUNT FOLIO NO.____

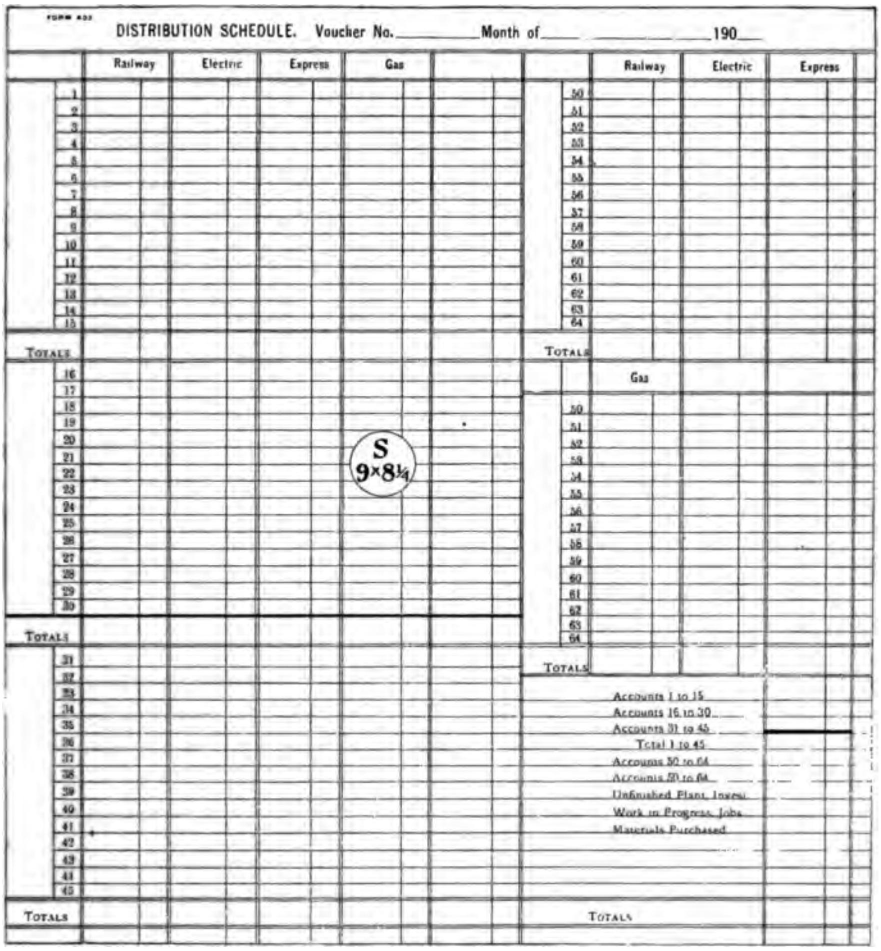
Please receipt this voucher and return to Auditor
with ALL PAPERS attached

REGULAR VOUCHER—FORM Q

BOUND IN TABLETS—Printed in copying ink, 100 to each tablet

VOUCHER SCHEDULE—FORM R

BOUND IN TABLETS—Printed in copying ink, 100 to each tablet



FORM [illegible]

DISTRIBUTION SCHEDULE. Voucher No.________ Month of____________ 190__

	Railway	Electric	Express	Gas	
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
TOTALS					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
TOTALS					
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					
41					
42					
43					
44					
45					
TOTALS					

	Railway	Electric	Express
50			
51			
52			
53			
54			
55			
56			
57			
58			
59			
60			
61			
62			
63			
64			
TOTALS			
	Gas		
50			
51			
52			
53			
54			
55			
56			
57			
58			
59			
60			
61			
62			
63			
64			
TOTALS			

Accounts 1 to 15______
Accounts 16 to 30______
Accounts 31 to 45______
Total 1 to 45______
Accounts 50 to 64______
Accounts 50 to 64______
Unfinished Plant, Invest.______
Work in Progress, Jobs______
Materials Purchased______
TOTALS

S
9×8¼

VOUCHER DISTRIBUTION—FORM S

BOUND IN TABLETS—Printed in copying ink, 100 to each tablet

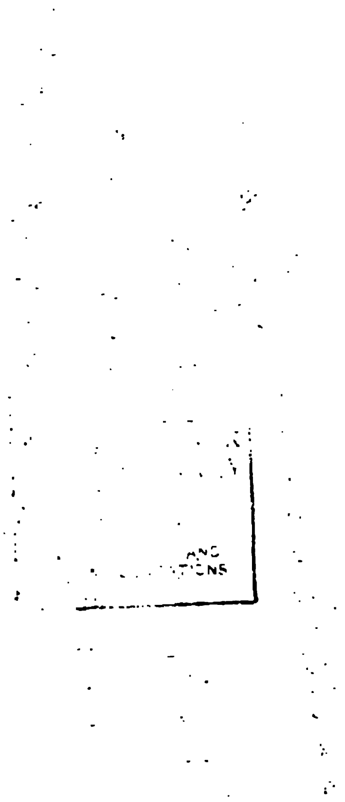
147

Month

1

1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	

Bound B
of


AND
TIONS

AND
NS.

AND
TIONS

147

Month

1
2
3
4
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7
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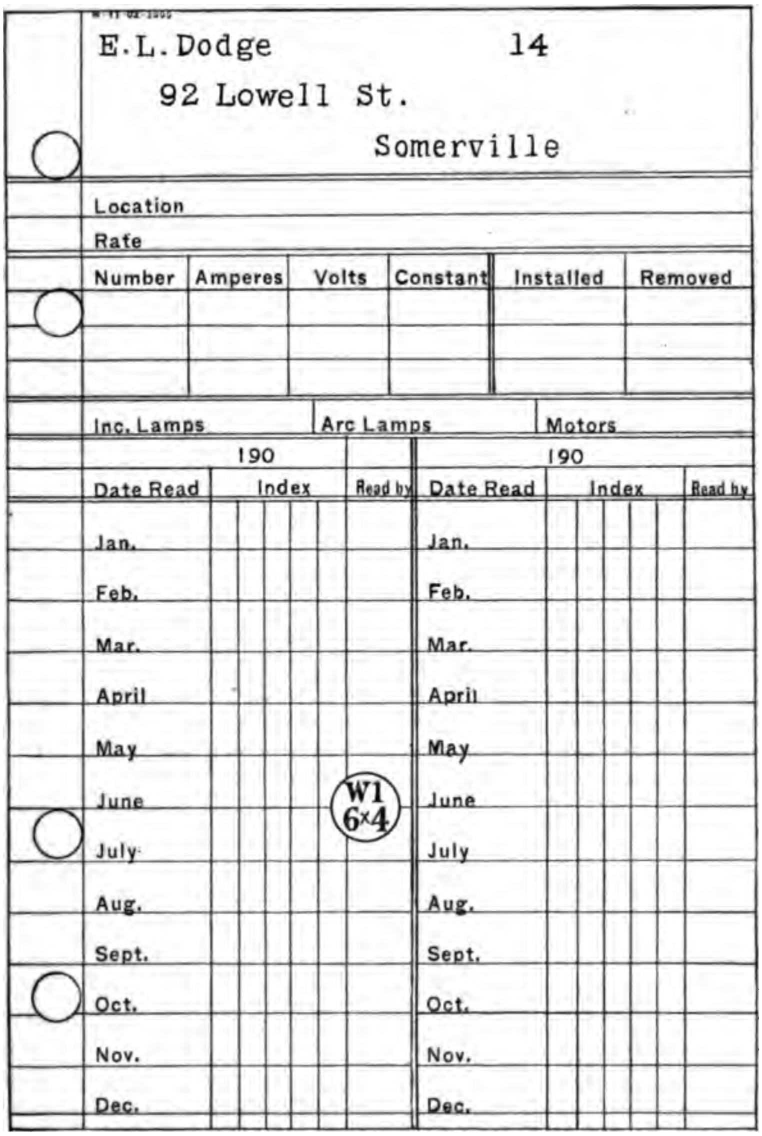
9
10
11
12
13
14

Bound
of
L



E. L. Dodge 14

92 Lowell St.

Somerville

Location

Rate

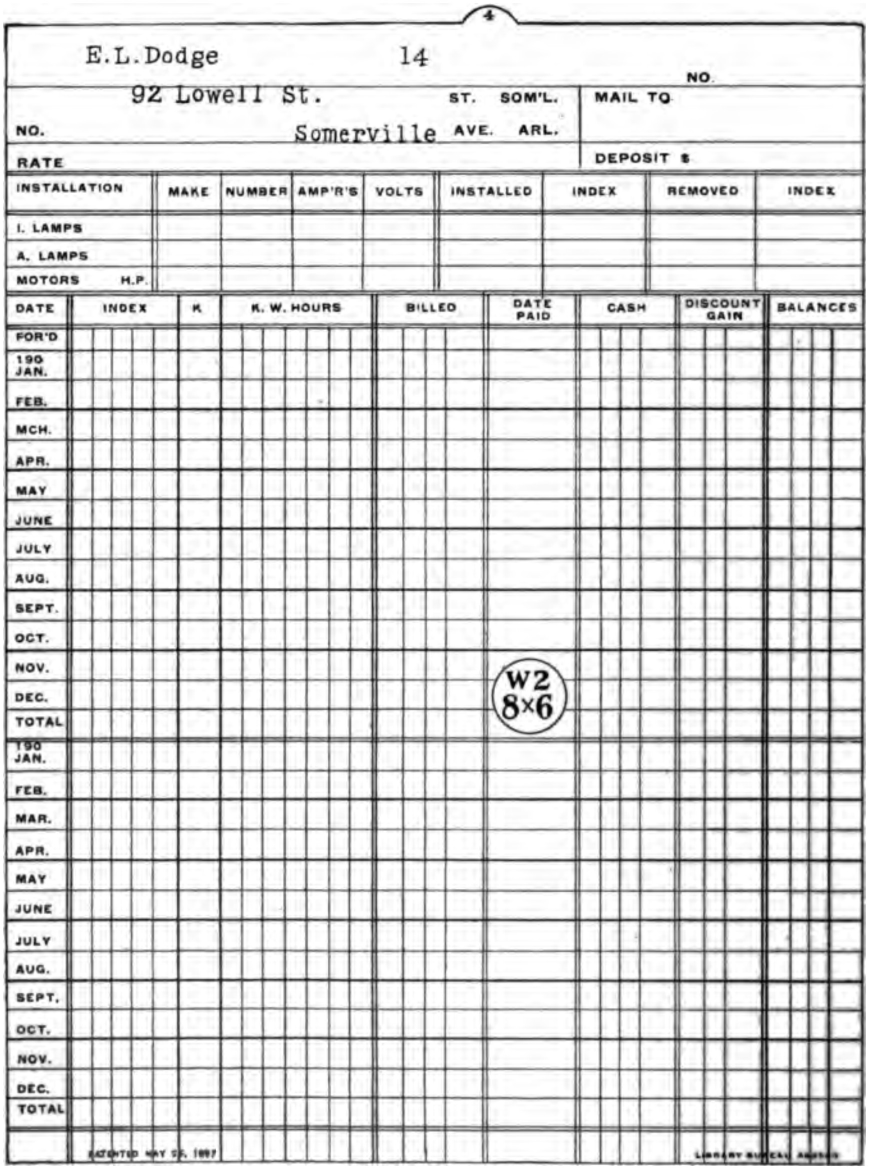
Number	Amperes	Volts	Constant	Installed	Removed

Inc. Lamps | Arc Lamps | Motors

190			190		
Date Read	Index	Read by	Date Read	Index	Read by
Jan.			Jan.		
Feb.			Feb.		
Mar.			Mar.		
April			April		
May			May		
June		W1 6×4	June		
July			July		
Aug.			Aug.		
Sept.			Sept.		
Oct.			Oct.		
Nov.			Nov.		
Dec.			Dec.		

METER CARD—FORM W1

Card System



4

E.L.Dodge 14

NO.

92 Lowell St. ST. SOM'L.

MAIL TO

NO. Somerville AVE. ARL.

RATE

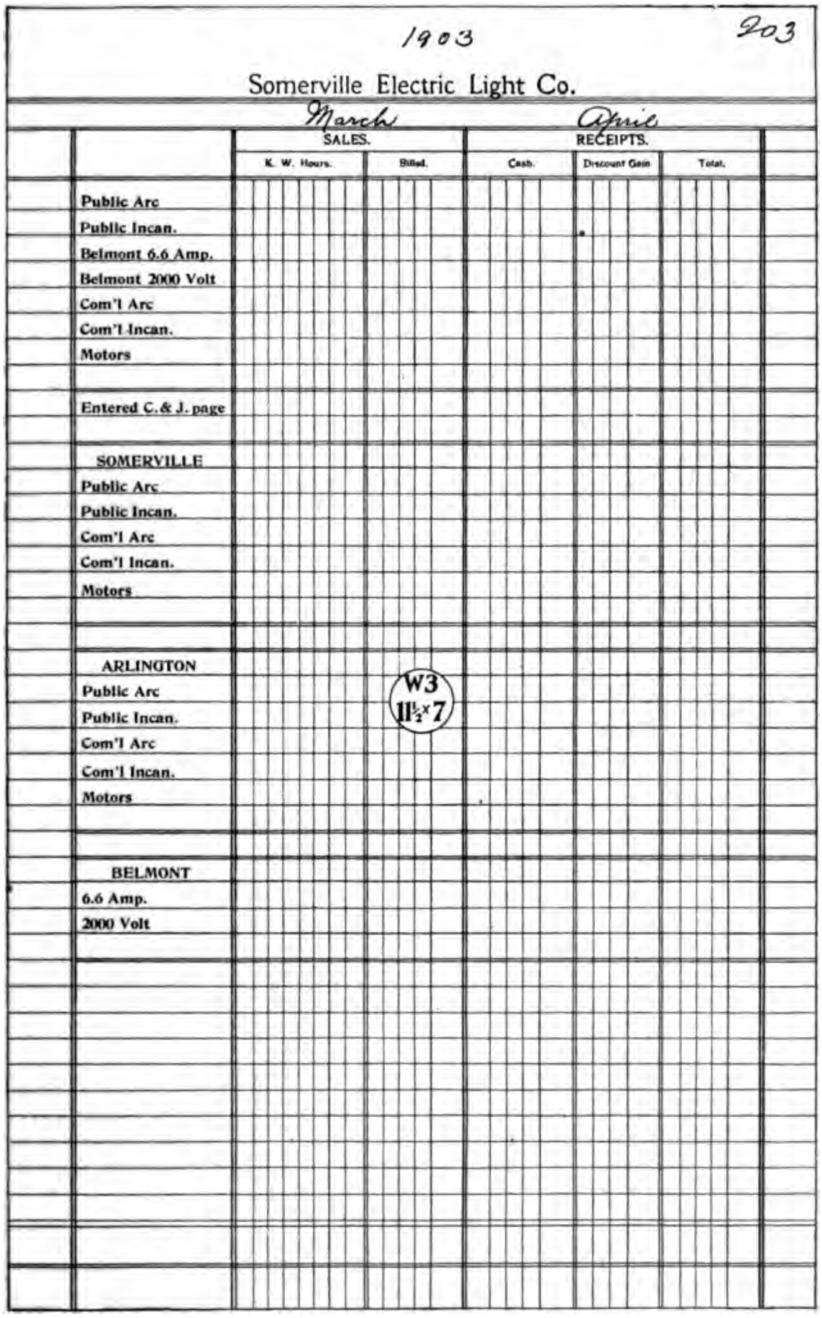
DEPOSIT $

INSTALLATION	MAKE	NUMBER	AMP'R'S	VOLTS	INSTALLED	INDEX	REMOVED	INDEX
I. LAMPS								
A. LAMPS								
MOTORS H.P.								

DATE	INDEX	K	K. W. HOURS	BILLED	DATE PAID	CASH	DISCOUNT GAIN	BALANCES
FOR'D								
190 JAN.								
FEB.								
MCH.								
APR.								
MAY								
JUNE								
JULY								
AUG.								
SEPT.								
OCT.								
NOV.								
DEC.						W2 8×6		
TOTAL								
190 JAN.								
FEB.								
MAR.								
APR.								
MAY								
JUNE								
JULY								
AUG.								
SEPT.								
OCT.								
NOV.								
DEC.								
TOTAL								

LEDGER CARD—FORM W2

Card System



1903

203

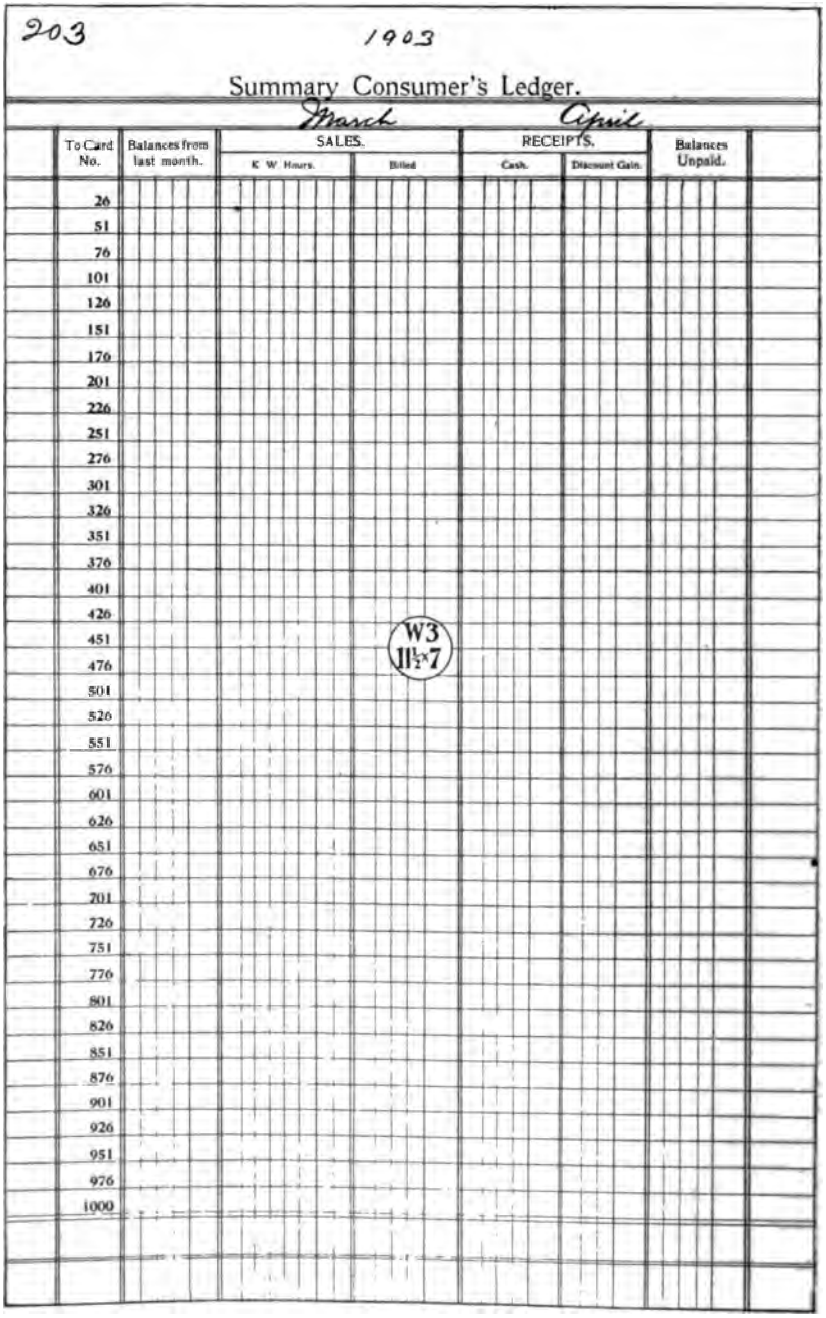
Somerville Electric Light Co.

	March SALES.		April RECEIPTS.		
	K. W. Hours.	Billed.	Cash.	Discount Gain	Total.
Public Arc					
Public Incan.					
Belmont 6.6 Amp.					
Belmont 2000 Volt					
Com'l Arc					
Com'l Incan.					
Motors					
Entered C. & J. page					
SOMERVILLE					
Public Arc					
Public Incan.					
Com'l Arc					
Com'l Incan.					
Motors					
ARLINGTON					
Public Arc					
Public Incan.					
Com'l Arc					
Com'l Incan.					
Motors					
BELMONT					
6.6 Amp.					
2000 Volt					

W3
11½×7

SUMMARY LEDGER—FORM W3

LOOSE LEAVES—Leaves to be bound in thin sectional post covers, or patented covers, as preferred



203 1903

Summary Consumer's Ledger.

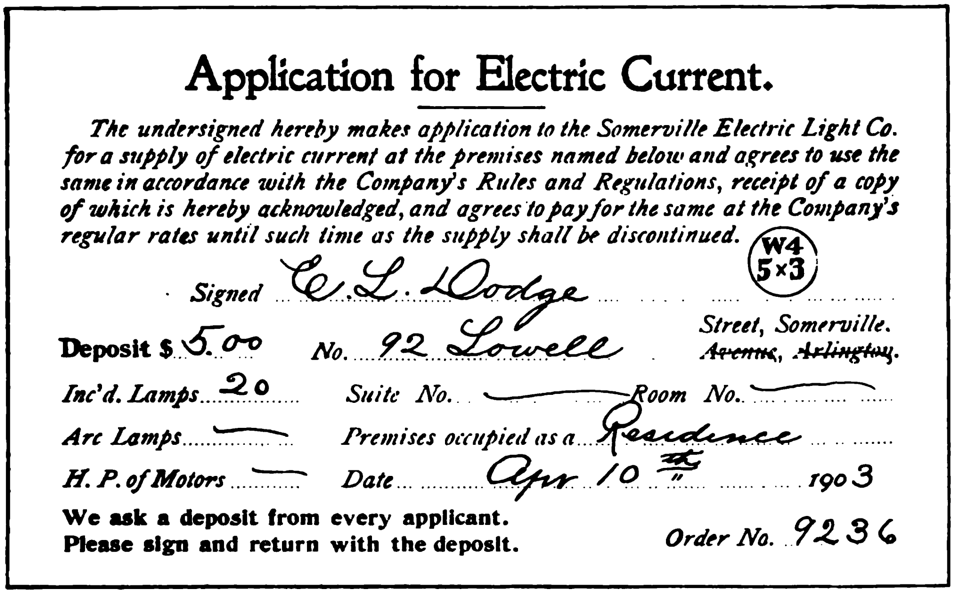
March April

	To Card No.	Balances from last month.	SALES.		RECEIPTS.		Balances Unpaid.	
			K W Hours.	Billed	Cash.	Discount Gain.		
	26							
	51							
	76							
	101							
	126							
	151							
	176							
	201							
	226							
	251							
	276							
	301							
	326							
	351							
	376							
	401							
	426							
	451							
	476							
	501							
	526							
	551							
	576							
	601							
	626							
	651							
	676							
	701							
	726							
	751							
	776							
	801							
	826							
	851							
	876							
	901							
	926							
	951							
	976							
	1000							

W3
11½x7

Summary Ledger—Form W3

Loose Leaves—Leaves to be bound in thin sectional post covers, or patented covers, as preferred



Application for Electric Current.

The undersigned hereby makes application to the Somerville Electric Light Co. for a supply of electric current at the premises named below and agrees to use the same in accordance with the Company's Rules and Regulations, receipt of a copy of which is hereby acknowledged, and agrees to pay for the same at the Company's regular rates until such time as the supply shall be discontinued.

W4
5×3

Signed E. L. Dodge

Deposit $ 5.00 *No.* 92 Lowell *Street, Somerville.* ~~*Avenue*~~, ~~*Arlington*~~.

Inc'd. Lamps 20 *Suite No.* — *Room No.* —

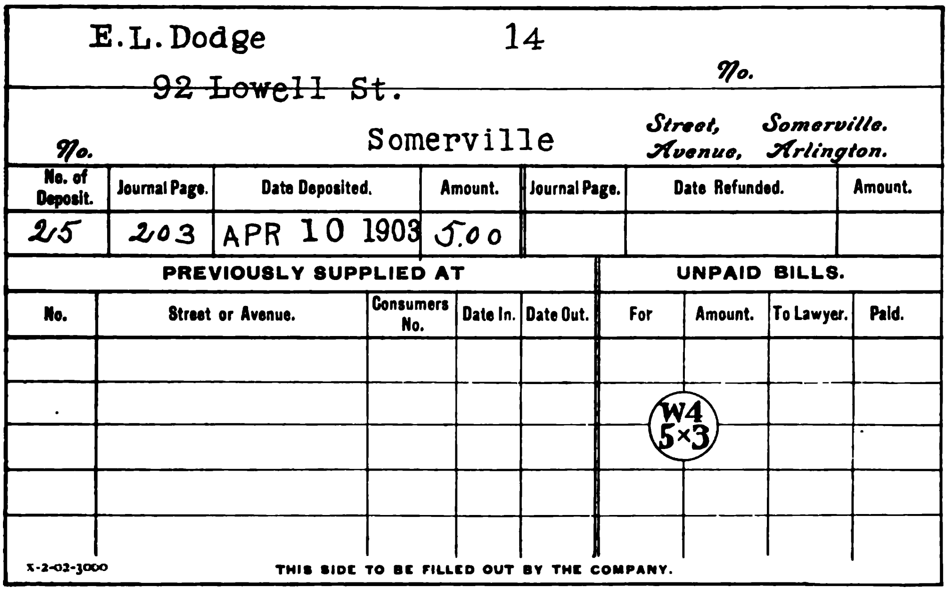
Arc Lamps — *Premises occupied as a* Residence

H. P. of Motors — *Date* Apr 10th 1903

We ask a deposit from every applicant.
Please sign and return with the deposit.

Order No. 9236

Application Blank—Form W4
Card System



E.L.Dodge 14

No.

92 Lowell St.

No. Somerville *Street, Somerville.* *Avenue, Arlington.*

No. of Deposit.	Journal Page.	Date Deposited.	Amount.	Journal Page.	Date Refunded.	Amount.
25	203	APR 10 1903	5.00			

PREVIOUSLY SUPPLIED AT					UNPAID BILLS.			
No.	Street or Avenue.	Consumers No.	Date In.	Date Out.	For	Amount.	To Lawyer.	Paid.

W4
5×3

x-2-02-3000

THIS SIDE TO BE FILLED OUT BY THE COMPANY.

Application Blank—Form W4
Card System

DISCUSSION

THE PRESIDENT: It is hardly necessary for me to say anything regarding this report; you have manifested your appreciation of it by your applause. The report has been written largely for the benefit of operating officials, because Mr. Anthony knows from experience the value of the system of accounting that he has outlined to an operating official. The report is open for discussion, and I hope we shall have a free discussion of it. After the discussion, Mr. Anthony, I am sure, will gladly answer any questions. The gentleman who is responsible for suggesting this report is an ex-president of the association, so I think it is proper that he should lead the discussion. I refer to Mr. Henry L. Doherty.

MR. DOHERTY: I do not know whether you expect me to make an apology for suggesting the subject or not. I do not think it is necessary. This report deals with an essential part of our business, the part upon which every other part depends. I feel glad to have been the suggester of this line of work, because I believe it is very important, and I congratulate Mr. Anthony upon his very successful paper. I did not expect to be called upon to discuss the paper, and, necessarily, my remarks will be more or less disconnected. On page 90, Mr. Anthony refers to meter cards, and says that the meter cards are the original source of entry, easy to carry and easy to refer to, but wisely do not contain any information as to discounts or billing; and valuable to refer to, because said meter cards, as a rule, contain several previous months' readings, which are a guide to the meter reader in taking future readings off the dials. We do not use this system to which Mr. Anthony refers, and we do use a system that is intended to prevent just what he wants to secure. We do not want our meter readers to know what the previous reading has been; there is a likelihood of their estimating the meter reading rather than making the reading. We use a card gotten up by Mr. S. J. Glass, formerly secretary of the Milwaukee Gas Light Company and now auditor of the American Light and Traction Company, and it is so arranged that when the meter readings have been copied the reading is torn off; we also inspect these cards at frequent intervals to see that the men are not turning over the cards and putting the reading down on some place where it will be left. To guard still further against estimates in meter reading, we have twenty-odd meter-reading routes, and we divide them into five main districts. Every month the meter reader on one district is rotated to the next, and in that way we protect ourselves from fraud; and you will find on record, especially in gas literature, some gigantic frauds perpetrated by meter readers.

Mr. Anthony speaks of the addressograph machine. I do not know whether he means the rubber-type machine or not; I have not found the rubber-type machine entirely satisfactory. In our plants some of our men still use the addressograph, but I think we have recently adopted the linotype machine more generally, having our names and addresses made on it; and that gives a very clear impression, which you do not get with the rubber stamps. Of late we have been using the Elliott addressing machine in one or two of our plants. It is the cheapest machine to buy, and it also proves the cheapest machine to maintain and operate. It is a machine in which the name is cut out on a paper stencil, mounted in a tin holder, and an automatic arrangement is used to push the stencils through and print the bills.

The Thexton sealing machine is new to me, and I should like to know more about its operation and, if permissible, its speed, cost, and so forth. Mr. Anthony speaks of the arithmometer. We have fixed up our arithmometers with a foot lever, and now we have a sketch out and are going to send it to the Burroughs people, to have another set of printing keys run down the side to print the folio. This is now done by hand, and it can be done more quickly and accurately by putting in the folio when the amounts are drawn off. I think it would be a valuable addition to the Burroughs arithmometer, for central-station work at least, and I do not know why not for other business. We find the Burroughs arithmometer slower than it should be. The slowness of operation of the keys, when compared with the typewriter, does not give results as fast as we want them, and we are making plans to increase the speed. There are some machines used in this work that have not been touched upon by Mr. Anthony, and I believe it would be of value to the members to have them spoken of, at least. I am not familiar enough with the work even to call some of them by name, or to tell who the manufacturer is. There is one calculating machine now on the market, made by the Spectator company, of 95 William street, New York. It is an excellent machine for multiplication and division work. The most valuable machine for central-station work has not been touched upon, and that is the Thacher calculator. This gives you accuracy in division and multiplication work and in proportional work to the fifth place, and has advantages over the Baldwin calculator—and numerous other calculating machines—where you are working with one divisor. You set your rule on the one divisor and you can then read off cost per thousand or cost per kilowatt for any of your aggregate amounts without resetting your machine. It is an extremely rapid machine and is sufficiently accurate for almost all kinds of work, and is always sufficiently accurate for reduction work.

I believe that the broad principles of accounting among central-station men are yet to be learned. The business has so many other branches that demand time that I doubt if the managers of central stations have given this subject as much thought as it deserves or as much as is generally given to it in other classes of business; there have been so many new matters forced upon us in other directions that this branch of the work has been neglected. I will take one example: It has been customary to take the generating cost, add it up and divide by the total kilowatts generated from the central station, and say that the cost is so much per kilowatt, regardless of whether it is arc current, alternating current, or direct current. In some work I once did in a central station, I found that the direct arc current was costing over two cents and the alternating current less than one cent, and the average cost was 1.52 cents. If we should take 1.52 and assume that we could sell direct arc current at a little above that price and come out whole, we should lose money. If we missed getting a customer because we believed the alternating current was 1.52, we should be losing by the omission. That illustrates fairly well—although I think I could find a more forcible example—the value of intelligent accounting—something more than bookkeeping. A bookkeeper means a copyist, and what we want is a thinking man to do our accounting. The result of that investigation is that to-day we divide every class of current and ascertain its cost independently, as we divide many other things, and the average man, looking at our report, would imagine that it entailed a great amount of labor. It does take some effort, but we can get our report out quicker than he gets his out, no matter how short it is, by the system that underlies it, and we do not think it costs us any more to get it out. It did cost more to organize the system originally, and the employment of many more peoples but to-day it goes on and does not require any more intelligence than the old form of report required. Two days from the last meter-reading date we have our net earnings, and we know what our earnings are. We tabulate a great many things—errors of meter readers and errors of bookkeepers—and keep them on the bulletin board in the bookkeepers' room. We have reduced the mistakes on meter readings from eight mistakes per thousand meters read to, I think, 1.4, which has been the average for the last six months. Most of the errors of the meter readers are caught by the bookkeepers.

Mr. Anthony: Mr. Doherty refers to the different ideas in meter cards. My experience in bookkeeping, as well as in everything else, has been that the more the employees know, the better off you are; and unless you are willing to give full information to all the people inside of your office, in the same way that I am giving information to this association, you do not progress very fast. Our meter readers, therefore, are expected, if a meter reading was small last month and large this month, to look again. Our meter department has no bookkeepers to check up this matter for them. Our experience has been that of the two systems, with a very large company, we are much inclined to the system we pursue. Our system has drifted into the "knowledge" situation, and we find that by employing a better class of meter-reading men we obtain better results. The more they know of the customers' readings, the more are they liable to ascertain anything peculiar about the meter or the reading, bringing information immediately to the meter department that the reading is too large or too small, or that it varies from the previous one. I think it is about as broad as it is long. Your system probably has advantages, as well as ours, but our business is based upon the principle of giving the greatest amount of information to the greatest number of our employees along the lines of their respective work.

As to the sealing machine: this machine will seal the envelopes as fast as any one can pass them through. It is a small machine, with a bedplate and blade along which the envelope slips, automatically feeding itself, and, as I recall, the cost is about $30. A sponge does the sealing. The addressograph is a good deal like other similar devices; if it is not kept clean and in good shape it is not satisfactory. We have ours kept to the pink of perfection. I omitted considerable, in reading the report, as to its functions. It runs through the whole gamut. It prints the meter cards, prints the meter sheets, prints the bill-heads, then the envelopes; and it prints also the customers' ledger sheets. We make the addressograph do a large amount of work, therefore we keep it in first-class condition.

My experience with the linotype was that we could not get speed. The Boston company, I understand, had the linotype for some time, but discarded it for the addressograph. In our accounting and other departments we have innumerable small devices, too numerous to mention. I think we have nearly all of which Mr. Doherty has spoken. To have included many more of these would have made the report too long.

The following question has just been handed me by a member of the association: "I was under the impression that a loose-leaf ledger was not considered legal evidence in a court of justice on account of the possibility of altering records or replacing the entire record." If you have only the loose-leaf ledger, what can the court do? Does it not become the original book of entry? We have never had any trouble in numerous court cases we have had where the loose-leaf ledger formed the only record. I do not think it cuts much figure. We would rather lose a bill once in a while than go back to the old method of keeping accounts in bound books. All the general books of the company—such as general cash, journal and ledger, are bound, and we rarely ever have occasion to take a loose-leaf register into court. We generally take our bound books, if necessary. The bound books are not the company's operating or detail books.

MR. SAMUEL INSULL (Chicago): I do not know that I can throw any light on this subject, except as to one point, which Mr. Anthony only referred to by inference. After all, all accounting systems are for the purpose of finding out where you stand, and my experience in dealing with small properties—and I deal as extensively with small properties as with large ones—is that you seldom find men running a small property with the slightest idea of what it is doing—whether it is making or losing money. I have struck cases of electric-lighting plants where the owners thought they were losing money and were glad to get out, whereas if they had had a decent accounting system and had followed proper methods and knew where they stood from month to month, they would have found they were making money. We who are operating the larger companies are interested in the value of the securities of the smaller companies, for the reason that if small electric-lighting properties generally stand high in the public esteem, it helps the value of the securities of the larger companies. This is invariably the case in any line of business. As there are such a large number of our members who operate small properties, I would recommend that they get a first-class accounting system in operation. I have in mind the case of a small property not far from this city. The manager of the company was in trouble with the board of directors because of his poor showing. I got Mr. Anthony to put a decent system of accounting in the company. At first the manager objected, and said there was too much red tape; it was all right for a big company, with a big gross income, but it would not do for them. After three months' running he thought it the greatest boon ever conferred upon him, and he has gone up greatly in the estimation of his directors because he can show month by month exactly where he stands. I desire especially to bring this side of the subject to the attention of the gentlemen here, representing properties with income varying from $25,000 to $50,000 per year. I have bought ten such properties in the past year, and in not one of them was there a proper system of accounting. It was to my advantage in a number of cases that there was not a good system of accounting; it enabled me to buy the properties for less than they were really worth. I can give no better reason for spending money in establishing a system of accounts that will show you exactly where you stand, exactly what your income is, and what the profit and loss is every month in the year. I think we owe Mr. Anthony our sincere thanks for the report that he has read. I do not know that I have listened with more interest to any paper of this character read at a convention of this or any other association than to the report of Mr. Anthony. I hesitate to say this concerning some one connected with our company, but I feel so strongly on the subject that I hope you will excuse me for blowing our own horn.

The President: I have seen many members making notes, and I should like to hear from some of the smaller companies.

Mr. G. W. Brine (Atlanta, Ga.): I want to ask Mr. Anthony whether disbursements that do not come under the head of purchase of material, such as contracts for labor, go through the purchasing department or not. Does everything in the way of disbursements pass through that department?

MR. ANTHONY: I believe the purchasing agent of the company should be the representative of the company on the disbursement side. Following out that idea, if you want to succeed in accounting and know where you are at, give him, and every official, the widest scope of information; do not keep anything back. Tell your people what a thing costs, as to their own work; they have no idea of the commercial value of the dollar until you show them such value. Consequently, all our contracts involving expenditures go through the purchasing department, although our president or second vice-president may make most of said contracts. Such contracts go through exactly the same routine as the purchase of material. In that way, one general rule is made for everything. Woe to the exception! Have no exception; you get results in costs by having no exceptions. In accounting, do not let the exception prove the rule.

MR. W. S. NEWMAN (Lambertville, N. J.): I represent a small plant, and read most of our meters, and I think it is an advantage for the meter reader to have the previous readings with him. I always figure out the amount of current used and compare it with that of the previous month, and if there is much difference I read the meter again and find out the cause. In this way I guard against mistakes being taken into the office and posted by the bookkeeper, for we all make some mistakes.

MR. BRINE: There is another question in regard to Mr. Anthony's report—as to invoices being sent to heads of departments. We have had a great deal of trouble from invoices not being returned when they are sent out in this way, on account of either having been mislaid or lost. Instead of sending invoices to the heads of departments, the storekeeper, or, in cases where material does not go through stock, the head of the department that the material is for, reports the material received, on regular printed form of notification sheet. If the notification sheet is not received promptly, we go after the department from which it should come; but the original invoices do not leave the purchasing department, the material being checked up with the notification sheets.

MR. ANTHONY: If the head of any department is not able to take care of his invoices, he is not able to take care of his department. Invoices represent dollars and cents, and you characterize the work of the representative in dollars and cents. The invoice represents cash in the pocket; if the representative can not take care of $5.00 in his pocket, he can not take care of the invoice. It is a wise thing to avoid all duplication. The invoice should bear on its face a complete history of the transaction, with the necessary signature of each head of department interested. If an invoice is held up in our company for more than twenty-four hours, there is a row, and we begin with the president; and the success of that situation is because the president takes the same medicine that he deals out to subordinates, for subordinates are prone to follow in the wake of their superior officers. If the president returns invoices promptly, you will find all others doing so.

MR. P. A. BERTRAND (Springfield, Mo.): In connection with the handling of invoices and receiving material, the material should be examined, to see if it is correct, before the invoice is paid. If the invoice does go through the proper channel, the question is whether the storekeeper is a competent judge of the quality of the material. There should be some method for having the material examined as well as the invoice. I think it is as important that the material should be of proper quality as that the invoice should be correct.

MR. ANTHONY: That is exactly on the same basis as the other question. Get a new storekeeper, or stop buying material. If you have people in your department who are not able to judge the quality of the material—to whom you send these invoices—they are not able to make proper use of the material. Nine-tenths of all our material goes direct to the storeroom and is receipted for—simply the quantity that is received—and there is always some one connected with the supply departments of which I have any knowledge who is able to judge of the quality of the material. If there is not, the mechanical engineer or the operating superintendent, or some one of the various other people, is called in. They are always interested in getting the material promptly—as a rule the mechanical engineers are looking for the material before it comes—waiting for it; therefore we have no difficulty of that kind in passing our material. I think our purchasing agent, Mr. Holmes, may give you more definite information.

MR. R. C. P. HOLMES (Chicago): The very reason why the invoice is sent to the different departments is that the men can see they are getting what they ordered on the original order. As Mr. Anthony says, 80 per cent of our goods goes into the storeroom, and is examined there and reported upon in the receipt book and the invoice returned to the office later by the storekeeper. All material for operating or small construction work goes to the construction foremen or engineers, and the invoice goes to them for approval as to quality and correctness of the invoice generally. The invoice is not approved unless the material is as ordered.

MR. BRINE: We get the same results on our notification sheets, which are simply a report of material received; they are numbered consecutively. In our case, also, about 80 per cent of the material goes through the stock-room and is reported on by the stock-keeper. The invoice itself finally goes to the heads of departments for approval; that is, the general heads. The material is reported upon on these notification sheets by the subheads of departments or by the storekeeper.

THE PRESIDENT: Am I to understand that the notification sheet is a copy of the invoice?

MR. BRINE: It is a report, from the stock-keeper or electrical engineer, of material received; describing it, condition, etc., but does not give prices. The invoice remains in the purchasing department.

THE PRESIDENT: Does not your head of department check the invoice?

MR. BRINE: That is checked by the general head of department.

MR. ANTHONY: That is referred to in the report by the so-called "arrival notice."

MR. B. A. CONOLLY (Lima, O.): I ask Mr. Anthony if the storekeeper should be under the direction of the auditor of the company or under the direction of the manager?

MR. ANTHONY: The auditor of the company should have general supervision of every department relating to expenditures and receipts. Regarding anything showing costs, receipts, expenses or disbursements, the auditor should have absolute jurisdiction. The storekeeper should come under the direct jurisdiction of the manager. He represents the manager more than he does the auditor. If the storekeeper does not do his work properly, the auditor should be able to call the manager down, as well as the storekeeper.

Mr. Conolly: Does the storekeeper, as a rule, keep the books of stock, in and out, prices, and when supplies go out; does he credit accounts in his books and make a monthly report to the auditor or bookkeeper, of the supplies used, for credit in general books?

Mr. Anthony: That is handled in different ways, according to local conditions, and the best practice is that which brings all the accounting in the accounting department proper. Our storekeeper keeps no accounts except number, pounds and feet of material asked for, and the number, pounds and feet received. Prices do not come within his category. The pay-rolls are kept in the same way: number of hours or days on work; account number or job number charged, and place work was done; and the man who makes the pay-roll is not necessarily supposed to know the wages received by the men. In that way you concentrate the maximum efficiency of each department where it belongs. Do not make mechanical men storekeepers, or operating men bookkeepers. Ask them for the simplest possible information necessary, *but insist on that*: number, pounds and feet; hours of work and class of work the hours were spent on. That is all we want of any one outside the accounting department. We in the accounting department furnish all other information as to what everything costs to our people, as they may be interested.

Mr. Conolly: The reason why I asked if the auditor should have charge of the storekeeper is that I have heard it stated that some managers are inclined to make a record. That is, on their statistical reports, where the supplies are charged off every month, four or five hundred dollars may be omitted, and at the end of the year, when you take an inventory, you may be five or six thousand dollars short; and if a new manager came in he would have to stand that deficiency by charging his operating expense account with it.

Mr. Samuel Scovil (Cleveland): Any one who knows anything about the trend of affairs, knows that all executive officials in any establishment of any size realize that they do not make much progress unless they know something about the details of the business they are managing; there is only one way to ascertain this, and that is by having a good accounting department.

My principal object in rising is to say that central-station managers have a grievance because the representatives of electrical manufacturing interests do not consult the interests of central stations in regard to representing the facts as to central-station costs. It may be that this is due to the lack of knowledge and to the fact that in meetings of this kind they hear statements that electricity is generated at a cost of one or two cents a kilowatt, and they consequently infer that it can be sold commercially at three or four cents. Occasionally some theoretical college professors, who imagine that they know all the ins and outs of the central-station business, are also led to make statements publicly, which delude many people, that electricity can be generated at one cent or two cents per kilowatt and that it can therefore be sold commercially to users generally at a maximum price of three or four cents, or some such ridiculous figure.

I am at this time up against that particular proposition. The gentleman who sent a report of this nature to the Common Council in Cleveland, I happen to see in this room, and I should be glad to have him make any remarks he sees fit in regard to it. I should like to have him given the privilege of the floor on this subject. He gave me the floor not long since in a municipal ownership convention.

We all know that it is ridiculous to talk about selling current to users generally at any such price. But it is by such misrepresentations—whether they be made intentionally or through ignorance — that municipalities are deluded into making large investments in new electric-light plants, and injuring existing properties that are trying to do the fair thing by the communities they are serving. I say this because I believe that central-station people should make it a point to be at least a little cool toward these professors and those manufacturing interests whose representatives misrepresent the costs of conducting the electric-lighting business.

MR. INSULL: Mr. Scovil should name the gentleman and let us know who he is. Mr. Scovil represents too large an amount invested in the illuminating business to have his statements taken lightly.

MR. SCOVIL: If the gentleman will give me the privilege I will name him; if he does not give me the privilege I will not do so.

PROFESSOR E. W. BEMIS (Cleveland): I do not know but that the reference was to me, but I think there was a slight misunderstanding.

MR. SCOVIL: The statement I made was that some representatives of manufacturing companies, and professors connected with colleges, and elsewhere, are often the authority for the statements publicly made that electricity is generated at a cost on the switchboard of one to two cents per kilowatt, and that because it can be so generated it can be sold at three and four cents a kilowatt by a central station to its users generally, and that I had this particular kind of proposition to deal with at present.

PROFESSOR BEMIS: Since my friend Mr. Scovil, for whom I have the greatest regard, has referred to it—I am here as a stranger and with your courtesy—I will relate what the circumstances were, as I understand them, that I may be put right. I think that when Mr. Scovil reads the report referred to he will find that I made no statement relating to costs. As superintendent of the water-works in Cleveland, I was called on to have something to do with a report that was made to the city by an electrician of another city, Mr. Charles E. Phelps, Jr., consulting electrical engineer and member of the Baltimore electrical commission. He was engaged by the city of Cleveland, and made a report which I transmitted to the council. I transmitted it without any attempt to make a critical analysis or discussion of any figures mentioned, and did not commit myself to any statement that electricity could be sold for three or four cents per kilowatt, as I think Mr. Scovil will find when he comes to read the report. I was very careful not to do that, for I recognized that, not being an electrical engineer, I was not competent to indorse any special figures. Whatever Mr. Scovil refers to must be in the report of Mr. Phelps, a member of the Baltimore electrical commission. Do you not recognize that as true, Mr. Scovil?

MR. SCOVIL: I think that in transmitting that report you said that electrical energy could be sold commercially for four cents, and that this was more important than the cost of a street light in the city of Cleveland; that electricity could be sold at four cents a kilowatt to users generally. Certainly, your report leaves that impression.

PROFESSOR BEMIS: I shall have to look up the report. I intended not to commit myself to his figures, but said I thought electricity could be sold somewhat cheaper than it had been, but did not refer to any definite statement.

MR. SCOVIL: I want to say that my relations with Professor Bemis have been of the pleasantest. I think we are all on good terms in Cleveland, generally. There is a general respect for the manner in which he has handled the water-works department, of which he is in charge. The statements made by these professors come from ignorance of the business, and I should be glad if Mr. Anthony could get at a lot of these gentlemen and show them what the real cost of producing and distributing electricity is.

MR. INSULL: Mr. President and gentlemen: To achieve what Mr. Scovil points out as a desirable thing—and we must recognize it as a desirable thing—we must go one step further than having a good system of accounting; it will be necessary to have a good statistical department. The accounting department gives average costs, but that is not all that is required. The point is whether a customer whom you are supplying burns electricity 150 hours in a year, as in the case of the large office buildings, or whether the customer has some manufacturing business, such as an electro-chemical process, and buys electricity from you and uses it steadily in about the same quantities 24 hours a day. The question of fixing costs must cover, besides ordinary operating expenses, the amount of interest and depreciation applicable to each customer per unit of output taken. I can take you two blocks from here and show you on one side of the street a customer on the upper floors of a light office building, and if you will add to your actual costs in the case of that customer the amount of interest and depreciation applicable to his particular case, it will be an absolute impossibility to obtain a rate per kilowatt that will give you back the fair expenditure you make every year for that customer. On the other hand, I will take you to the other side of the street and show you a customer whose average consumption is about 3,000 hours a year, and your cost in his case will be so low that you can afford to sell to him at the price that Professor Bemis, or the gentleman he quoted, or some one else, said is the price at which you can sell current. Or, to apply this idea to a small company in a small town, there are a number of cases where the electric-light companies supply current to street railways. Their load factor is at least 50 per cent; that is, their average use of the current is 50 per cent of the maximum. The customer next door may be a man who has a few lights and never burns them more than three hours per day at the very most; probably his average during the year would run below that. In one case you can afford to sell at a very low price, because your interest and depreciation is divided by a great many units, used comparatively steadily over a very long period. In the other case, if you sell current at 20 cents a kw-hour, unless you have a very economical station you stand a good show of losing money. There is no business in which the question of costs and selling price varies more than in the electric-lighting business. Our cost in starting the business is very high; we have to keep an investment necessary to take care of the maximum demand on us, and the measure of our interest account and of our depreciation is a percentage on the investment to provide for the maximum demand. The statements made by most of the theoretical engineers, dealing with subjects of this character, with regard to the cost to municipalities in conducting a business of this kind, are simply absurdities. The great trouble is that municipalities do not find this out except by experience. It is as impossible to supply small consumers, with a low average burning, at three or four cents per kw-hour, as it is to get five-dollar gold pieces for four dollars. Professor Bemis has had some experience in operating the water-works in the city of Cleveland, and I will draw an analogy from the water-works business. Suppose you have an inexpensive reservoir attached to a water plant, and are able to pump the same amount of water day in and day out, your average cost for pumping will be low, figuring not only the bare cost of production, but also interest and depreciation. Suppose in another town you have no reservoir, and have to pump according to your load. In that particular case your pumping plant would be large, your cost would be very high. And the same conditions that apply to water in that respect also apply to electric light.

I think the point brought up by Mr. Scovil is important to all of us. Almost all the public discussions on the cost and selling price of electricity drift into a discussion of municipalization of public-service industries. I think there is nothing that would check that general drift so much as a true knowledge of cost and selling prices; and that knowledge is not possessed by the people, or is ignored by the people, who are operating most of the municipal plants throughout the United States at the present time.

MR. W. WORTH BEAN (St. Joseph, Mich.): Mr. President, what I intend to say is not going to be germane to the subject, but I expect to take only two or three minutes, and I presume you can permit it.

The President: Mr. Bean, proceed.

Mr. Bean: I am glad to know that the lamb and the lion have lain down together; I am also glad to know that Professor Bemis is in the convention and that he and Mr. Scovil are friends. Professor, did I not understand you to say that in transmitting a report to the Cleveland council, stating that electricity ought not to cost over four cents per kilowatt, it was not your report, but a report of Mr. Phelps, of Baltimore; and that you are not an electrician, and do not know anything about electricity, and that you sent the report without recommendations?

Professor Bemis: It may be that in the letter of transmission there might have been some indorsement of the idea that for power purposes Mr. Phelps' figure of four cents was possible, but I think I avoided any reference to figures.

Mr. Bean: Professor, I should like to have you answer a question for the benefit of the association. If you are not an electrician and do not understand electricity, why have you propagated your doctrine all over this country for the last twelve or fifteen years, telling people and municipalities what it cost to produce electricity, and that municipalities can do their own lighting cheaper than private companies can do it for them, when you do not understand anything about it? (Prolonged cheers.)

Professor Bemis: I think I am enjoying this, if the convention is, but I do not think I should take your time. I have attempted, more as a statistician than as an electrician, to gather some information, and have tried to be fair and accurate in my publication of it. I have never claimed that I was a technical electrician and I do not claim so now. I did not suppose when I wandered in here this morning that I was going to divert the discussion from what I have been greatly interested in and indorse—for no one can appreciate accounting more than myself, and I think it is tremendously lacking in municipal plants and in private plants also. I think it is lacking, more or less, in plants all over the country, although there are brilliant exceptions. I certainly hope that I have never been unfair in my treatment of the subject. If I can answer further questions, I shall be glad to do so, but I do not think there is any necessity for going into personal discussions this morning. I am quite sure that Mr. Scovil did not intend to precipitate this discussion.

Mr. Bean: Mr. Scovil may not have intended to precipitate this discussion, but it is a serious question to each member of this association, and to every central station, that by the passage of laws by the various state legislatures their property has been indirectly confiscated; and all brought about by these people who do not understand electricity and the question of costs. If Professor Bemis, formerly a professor in a college, does not know what it costs to produce electricity, how can the laboring man, who uses the pick and shovel, be expected to vote intelligently upon this subject and understand about it when he reads it in the papers?

I do not want to divert the attention of the association from the report we are now considering. But what good will the report of the convention be if our business is to be taken away from us? The essential thing is that we have fair and clean-cut statements concerning our business, as we have a decent business to run and that is all that is needed. I understand from the report of Mr. Martin this morning that there are in this country over 3,800 central stations, and that over 800 of them have been municipalized. If all of the central stations in this country are to be run by the cities, and our business is to be practically confiscated by such misrepresentations, we want to know it. This is not germane to the subject, but it is the most vital thing that we can consider. When the convention adjourns, I want to meet Professor Bemis. He has interfered with my business seriously; no doubt he did not intend to do it, but the results are just the same. I want to congratulate the professor upon entering on another field—in the water-works line—and if he has had no more experience in the water-works business than he has had in the electric light, I want to give him my hand and lend him what assistance I can in operating the water-works—all based upon my experience, which is nothing. Further, I do not believe that municipalities can operate water-works to the financial interest of the taxpayers. I trust that we may be of some benefit to the gentleman in his new departure. If the municipalities do not know any more about the cost of operating water-works plants than they do about electric-light plants, it is time to call a halt and save the taxpayers' money.

The President: Gentlemen, I think the records of this session, this morning, will show fully the value of Professor Bemis' criticisms and statements and of his report. I do not think we need go further into this discussion.

MR. F. ELLWOOD SMITH (Somerville, Mass.): The paper read by Mr. Anthony is interesting to me, and personally I feel honored by the reference to the Somerville company. There is one point in reading meters that I found useful in former years, although we have now abandoned it; but for a small company with less than 500 consumers, I should certainly use the system of which I speak. When the meter-reading time comes, make out the customers' bills, write the name and address and the previous meter reading. The bill has a stub, which is perforated. Send your superintendent, or your bookkeeper or electrician—some competent man, you do not have a large force—to read the meters, and put the reading on the bill and on the stub. The bill is made out on the spot, and collected if possible. Tear off the stub and bring it back to the office and make your entries from the stub. The work of collection is done at the time the meter is read and saves an additional trip; and with a company having less than 500 accounts it will be found very useful, and a great saving of time.

MR. J. F. STRICKLAND (Waxahachie, Tex.): I have been much interested in Mr. Anthony's paper. I operate some small properties in Texas, and while I think the points made by him apply largely to larger properties, there are many practical points for the small stations as well. It occurred to me that he got on both sides of the proposition as to the information he would give employees about the station, both in his paper and in his answers to questions that have been asked. His first proposition was to give each employee filling the respective places mentioned all the information necessary for full knowledge of the business. My observation has convinced me that the average man connected with a small station should know only that part of the business that pertains to his personal responsibility in connection with it. That, he should know well, but he should not know that which should be known and handled by some other man connected with the business. The different branches should be divided and the duties and responsibilities divided, in keeping with the system he outlined in the report. In answer to a question, he stated that it would not do for the men handling the material to know about the cost. At that point, he took the other side of the proposition.

In connection with the meter-reading proposition, reference was made in the paper to the collection of bills. That interested me much, as it is getting close to where we are getting our money. I operate some small plants in Texas with less than 500 customers each. We read meters and collect our bills once a month. The bills are not large, and the more losing items we can shut out, the better the balance sheet at the end of the month. Even though I operate small companies, the first of each month shows me the cost per kilowatt, gross revenue received and net per kilowatt received for the preceding month. In order to protect ourselves against loss with our meter customers, we require a deposit to the full value of the meter. We do not approach a customer and ask him for a deposit on his account; human nature is the same the world over—no man likes to put up something unless something is put up on the other side. We issue a certificate for the amount of the deposit and retain the ownership of the meter. He can not move away from the city and discontinue the use of current without first settling at the office, because the certificate is not transferable. We protect ourselves in this way. I should like to hear from Mr. Anthony how they protect themselves against loss. We do not lose one-half of one per cent in the total year's business.

MR. ANTHONY: I think Mr. Strickland misunderstood me in one way. What I meant was that if an operating engineer operates a station he should be advised by the accounting department exactly as to the cost of operating his station, or the classification of what it costs to operate, as far as he goes, and that is all. I do not give him information as to what the costs are in some other department unless it is necessary. He should know what he is doing, in order to do better this month than last.

With regard to deposits, you can handle that question with better grace in a small city than in a large one. The less you stir up the deposit question with the public, the better for the company. We find in Chicago that we can not judiciously ask for deposits from many customers in the first place, and we will not put them on the system without a deposit, in the second place; consequently, we have instituted a series of weekly meter readings, and if none of you have tried it I should advise you to look into it. It is on the basis that 90 per cent of such customers will object strongly to paying a bill of $4.00 monthly, but will pay $1.50 per week and think it is fine. In case of default all you lose is one week's bill; $1.50 instead of $4.00. The difference between $4.00 and four times $1.50 is well worth waiving the deposit and doing a little extra bookkeeping. Where you can avoid the deposit, especially as cities become larger, I believe it will be wiser for the company. Avoid everything in a public utility corporation that in any way brings the customer up against the company in any but the most agreeable way.

MR. E. F. McCABE (Lewistown, Pa.): Have you tried the prepayment meters?

MR. ANTHONY: Yes.

MR. McCABE: With what results?

MR. ANTHONY: I would rather have Mr. Gilchrist, if he is here, answer that question.

MR. McCABE: Why not use a prepayment meter instead of going around every week and making out a bill; and why not use the prepayment meter instead of asking the customer to make a deposit?

MR. ANTHONY: Because you have as many different kinds of customers and different ideas to deal with as there are sands in the sea. If we can get customers with the prepayment meter, in it goes; if the weekly system suits them best, they get that: they have their choice. It is like the lunch counter—"pays your money, takes your choice."

MR. BEAN: I undersood the gentleman from Texas to say that he required a deposit for his meters. At $12 per meter, say, 500 customers would be $6,000. In our town they would consider that to be taking undue advantage of them, but I am glad to understand that in Texas they submit to it.

MR. STRICKLAND: For the benefit of the gentleman, I will say that our rates in Texas are based in such a way that while the customer realizes that he has to put up the value of the meter, we give him to understand that the rate quoted him includes a return for the use of his money; we present it to him in that way. We receive about 35 cents per inhabitant per month; the entire population of the city is about 6,000. Our receipts run about $2,200 or $2,300.

MR. ANTHONY: I will say, as to deposits, that our company, having 30,000 customers, has only about $12,000 on deposit. We do not run the deposit plan very hard.

MR. ARTHUR WILLIAMS (New York): Do you pay interest?

MR. ANTHONY: Yes; five per cent.

MR. E. F. PECK (Schenectady, N. Y.): I wish to testify as to the efficiency of Mr. Anthony's accounting system. The

Schenectady Railway Company has had most satisfactory results from the use of this system, which was adopted by the company the first of last January. The preparation of our monthly statement was formerly looked forward to with considerable anxiety and uncertainty, but we now look forward to the end of the month with pleasure, feeling certain that we shall secure accurate data. We have also been able to reduce our operating expenses some eight per cent, due to the fact that we are able to make a careful analysis of our accounts, which was impossible under our old system of bookkeeping.

Mr. Williams: As Mr. Gilchrist has not replied to Mr. McCabe's question, it might be well to say that we have not found any prepayment meter that has given results entirely satisfactory. We should like to have one.

Mr. Gilchrist (Chicago): The difficulty we find in using the prepayment meter is that, on account of its construction, when using it we must deal with the customer on the list-price basis. We have probably 125 to 150 of these prepayment meters in use. We look upon them more as pioneering devices than as affording a permanent arrangement under which to do business. We find many irresponsible people who are unwilling to make a deposit; others who are unwilling to agree to a minimum charge of $1.00 per month per meter; and to these people we submit a prepayment-meter proposition. This proposition involves no minimum bill and under it no deposit is required, but in doing business upon this basis it is with the understanding that if we do not receive a reasonable income for several successive months, we are at liberty to discontinue the service. In ordinary cases we, after a month or two, find the customer ready to make an arrangement on the regular contract basis, having been worked up to the use of electric light.

The President: We shall have to close this discussion, on account of the lateness of the hour. Mr. Insull desires to make an announcement.

Mr. Insull: The Commonwealth Electric Company extends to the members and guests of the association an invitation to visit the new turbine station we are building. The station is in course of construction. We had hoped to be able to show a turbine in operation. The turbine is now on the cars, coming from Schenectady. You will find a good deal to interest you in the station, and the president will announce some time to-morrow an excursion up the Chicago River—which is very picturesque—to visit our plant. We hope you will all go.

(The meeting adjourned until two o'clock.)

SECOND SESSION

President Ferguson called the meeting to order at ten minutes after two o'clock, and announced the first business of the session to be the paper by Mr. Sidney Hosmer, of Boston, entitled "Advantages to Be Derived from Consolidation of Electrical Interests."

Mr. Hosmer read the paper, as follows:

ADVANTAGES TO BE DERIVED FROM CONSOLIDATION OF ELECTRICAL INTERESTS

The advantages to be derived from any form of consolidation of manufacturing interests are properly divisible into three classes: (1) The advantage of the lower capital investment, (2) Lower cost of production, and (3) Better service. To these should be added, in the case of the transmission of electrical energy, the advantage to be derived from an improved load factor, which is almost certain to result from a combination of different classes of business. This improvement of load factor of course affects the matter of capital invested and also cost of production, but it is an advantage that applies to electrical consolidations in addition to those that may apply to any other forms of consolidation.

In all cases where such consolidations have been effected still another point has been gained, though it is not due to the mere combination; that is, the small plants have in almost every case been old and equipped with inefficient apparatus, while the consolidated plant has been of the most modern type and built under such conditions that the best engineering talent was available.

In the matter of invested capital, actual figures are hard to obtain. Taking the generating plant itself we know that plants of 15,000-kw to 20,000-kw capacity can be built for $90 per kilowatt, while plants of approximately 500 kilowatts run as high as $200 or over, due, of course, to the smaller units employed. Going above 20,000-kw capacity, the comparison would not continue to show such marked gain. In this station we have reached units of a size where cost per kilowatt ceases to fall very rapidly, and where great structural complications and expense may begin, due to the fact that boiler units are not increasing in size. Taking the distributing system in the case now being considered, there would probably be a slight loss, as we have obtained the load for the larger plant only by including greater territory, and this must inevitably increase the cost per kilowatt capacity.

A number of companies operating in a number of centres would have their lines installed in proportion to their business, and only small capacities running out to the edges of their territories. The lines between these various centres would have to be strengthened without a proportionate increase of business, and a certain amount of waste territory would have to be covered. Here we find the question on which turns the decision whether the larger company shall have one or more plants.

It is the almost universal practice to-day to run everything from one station, using substations for the transformation necessary for the supply of local districts; this may be proper so far as it has gone, but a point will be reached where the cost of lines and substations, with the liability to interruption in each, will not only justify but will demand a number of generating stations located with reference to the demand for current. The question of when this will be justified will depend entirely on coal and water facilities.

This question of distribution of plants, of course, only comes in where area supplied is very large, and where transforming apparatus becomes very expensive. We know of only one case where this policy has been carried out consistently; that company (a railroad) has located stations all over its territory, a majority of them under 5,000-kw capacity and a number of them without railroad facilities for coal. In the matter of size of plants, this is without doubt an extreme, but we should like very much to see their exact figures on investment, and also their cost of production.

We come here, also, to the question of safety and reliability. There is a limit to the amount of power it is desirable to put in one building. It has been demonstrated a number of times in our large stations that accidents can happen which will interrupt the entire plant. What this amount should be, will depend largely on the character of service supplied. On the one hand it should be as small as possible, so that any accident may affect as small a percentage of supply as possible; on the other hand it must be large enough for any possible demand for current to be met without difficulty. A plant supplying feeders of normal capacity of 700 or 800 kilowatts could be divided into units of 10,000 or 15,000 kilowatts without sacrificing any of the advantages of ample generating capacity, while a plant supplying feeders of 2,000 kilowatts would have to be made in larger sections to give equal service.

In most cases it will be impossible to find a number of locations having good coaling and water facilities, so that a subdivided plant at one point may be preferable; of course, aside from coal and ash-handling machinery, there are no arguments from the investment standpoint to justify putting all the plant at one place; while, on the other hand, distribution investment might be very much reduced by a number of generating stations at different points, provided always, of course, coal and water can be obtained. The Boston Edison Company is now erecting a plant for an ultimate capacity of 50,000 or 60,000 kilowatts. The situation there with reference to coaling and the shape of territory supplied is such that there is no choice but to locate the entire plant at one place. It is, however, the intention absolutely to divide that plant into at least three divisions, even to cutting the 'bus-bars for the separate divisions. Of course, arrangements will be made for so connecting the 'bus-bars that they may all be supplied from one section at period of light load.

Turning now to the question of lower cost of production, we find in station cost alone a very marked gain, amounting to a difference of 500 or 600 per cent between a plant of 500 kilowatts and one of 20,000. It is, of course, unnecessary to go into any discussion of how this is made up. In this respect, improvement should be found in consolidation, continuing also in the same ratio no matter how large the plant may become. A subdivided plant may cost a little more to operate than one not subdivided, but the difference will scarcely be appreciable. This would be almost as true for a number of generating stations if they were properly interconnected.

In the distribution of the consolidated company there might be some small gain in expense, but it could not be a very marked one. This expense is a function of the number of subscribers and miles of wire. In the consolidation, the miles of wire would certainly be increased for the same customers with consequent increase of expense of maintenance. If anything were gained here, it would probably be at the cost of increased investment; that is, the larger company would perhaps install the distribution plant better and in a more lasting way, but at greater cost.

In general expense and management, we could hardly expect much improvement, owing largely to the fact that responsibilities are largely increased and more complicated legal questions are brought in.

Taxes would of course be decreased in such measure as we have saved investment.

In the purchase of supplies and apparatus, there should, of course, be a great improvement possible; but this would be somewhat counteracted by the fact that the larger company would require a much greater number of articles to be carried on hand and a considerable investment must necessarily lie idle.

Turning now to the quality of service, we find the small company almost invariably running without spare apparatus and the service liable to suffer if anything goes wrong. This is probably partly due to the fact that it is a greater burden for the small company to buy extra apparatus, but it is probably in a greater measure due to the character of management under which it is run. The management of the larger company has a greater appreciation of its responsibilities and realizes more thoroughly that development depends on reliability of service. This defect goes with the smaller company because it is smaller and the margin of profit is less, and less can be put into management, etc., and not, as may be argued, because the company is old-fashioned and poorly handled.

Another defect that we find in most of the small companies, which is not due to the mere fact that they are small, is the absence of modern methods and devices, owing to the fact that the plant usually is old, and capital is not always available to take advantage of the newest developments.

The question of 24-hour service also comes in. In a 500-kw plant, it costs as much to run one unit as it does to operate the whole station in all except coal; as there are at most only two or three men to a watch, the long hours at very light load are an impossible burden. On the other hand, the cost in a large station varies in all things approximately with the number of units in use, and kilowatts produced at light-load times bear the same relation in cost to those produced on the peak. The difference in load factor between a small and large company comes in here also. A company supplying a great territory includes a number of different classes of business—residences, amusements, factories, and possibly street railways—so that the cost per kilowatt may be just as good at one part of the day as another. Also, one company taking the place of several does not necessarily get the sums of the peaks of the different stations, as these may not coincide.

DISCUSSION

The President: The paper by Mr. Hosmer is now open for discussion. I will ask Mr. Peter Junkersfeld, of Chicago, to start the ball rolling.

Mr. Junkersfeld: I do not know that I can start the ball rolling very fast, as Mr. Hosmer's conclusions agree closely with those reached in Chicago. During Mr. Hosmer's reading of the paper one point came to my mind with regard to the development of these large systems. He mentions the inadvisability of operating a number of smaller stations against one large station. The question of doing away with and shutting down the machinery in the existing stations is understood better to-day than formerly. In fact, with the present state of the art, this machinery in the old stations, operated during a few hours per day in a few months of the year, is worth almost as much to a central-station management as the equivalent capacity in machinery in a new station. This applies also to stations in small cities close together, provided their distributing systems are such that load can be shifted from one to another, and often results in a considerable saving in operating expenses by making a comparatively small investment.

Mr. Hosmer also made a point of the small amount of power it is practicable to handle in one station, and suggested dividing the station in very much the same way as we are doing here in Chicago. There is no doubt, of course, of the great advantage in the latter case in doing away with a large amount of unproductive investment that must be carried with the smaller stations. Take the situation in a large city; the more power that can be generated in one locality, the less will be the amount of unproductive investment and unproductive labor that has to be carried. It goes without saying that in a large number of stations there is a certain amount of attendance, and things of that kind, that can be greatly reduced in one or two large stations operated during the long-time periods.

The investment in substations and distributing system is becoming independent of the number of generating plants, and the transmission investment is, after all, a small part of the total. In some cases that have come under my observation it rarely runs higher than six per cent of the total investment that the company has made, so that the location of a large station where the transmission voltage is high enough to be economical for that condition does not cut such a big figure after all. The low-tension investment or distribution network would be very nearly the same, regardless of the number of generating stations, where these stations generated at a high voltage and the current was distributed through substations. The location of the station is more independent of the location of the load than formerly; that is, so far as operating costs and fixed charges are concerned.

In the matter of reliability of service rendered, it is often disputed whether or not with a large station we can secure and guarantee the same reliability as formerly. That, of course, in a large station means a better class of engineering and construction work and a better class of machinery than has heretofore prevailed, the reasons for which are obvious.

These precautions may be carried further by the judicious use of storage batteries, the subdivision of the station, and extra care in operating the entire system. I think this part of the proposition has been very clearly outlined and that the tendency toward operating one or two large subdivided stations during the long-time periods must inevitably grow in large cities and in smaller cities located close together.

THE PRESIDENT: We have heard from Chicago on this proposition, and we should like to hear from New York. Will Mr. Lieb give us his views?

MR. J. W. LIEB, JR.: Mr. President, I am sorry I can not discuss Mr. Hosmer's paper intelligently, because I happened to hear only the concluding paragraphs; but I should like to emphasize one or two points that Mr. Junkersfeld has referred to—the influence of unproductive labor and secondary labor costs in the multiplicity of small stations, as against one large power plant. In advancing from a number of small plants, which have been supplying a system, to one central power plant, if these plants have been turned over, as is usually the case, without providing for continuity of service by tie lines and other precautions against failure of service, it will be of extreme importance in a large centralized power plant to guard with more than usual care against failures and interruptions of service. While the liability to failure of underground transmission lines is probably not so great as represented, and the destructive effects of a high-potential arc are not so severe as would perhaps be imagined, on account of the lesser amount of current involved, yet, as regards the stability of the system as a whole, the liability of surging and the development of resonance effects in the system are such as to make it necessary to use unusual precautions for protection against breakdowns. In addition to the usual methods of duplicating paths followed by underground transmission lines, secondary tie connections should be established from station to station, to afford additional paths for assistance between distributing stations. It is probable that the best arrangement in the relation of substations to such a central transmission station has not been developed; whether single-'bus or two-'bus operation is preferable, or the separation when desired, into separate units by means of switching-gear, or a still further separation into practically single-unit operation, each unit supplying independently a station or group of substations, the future only can determine. It is probable, however, that supplying each substation through independent sets of feeders, following two courses and having the central station so arranged as to secure two-'bus operation, will supply a reasonable amount of safeguard without detracting too much from the economies to be obtained from operating the units in multiple. I need not refer at this time to the importance in such a system of an adequate storage-battery equipment as a safeguard against short interruptions of service, because as central power-plant development increases with larger concentration of power, such a necessity impresses itself in an increasing measure. I am sorry I can not refer specifically to the points in Mr. Hosmer's paper, because, as I said before, I did not hear the body of this paper.

THE PRESIDENT: There must be others of our members who are acquainted with the advantages of the consolidation of electrical interests in any given locality. If there is no further discussion of this paper we will pass to the next business and take up the paper on "Boiler and Furnace Efficiencies," by Mr. A. Bement, of Chicago.

Mr. Bement read an abstract of the following paper:

BOILER AND FURNACE EFFICIENCIES

It is not the object of this paper to treat of boiler and furnace efficiencies in general, but to discuss some features of the performance of modern standard apparatus. For this purpose two types of boilers, two furnaces and one stoker have been selected; one of the boilers, however, owing to changes made in it, may be considered as a third type. One of the boilers is 12 tubes high and 16 wide, provided with a superheater and rated at 400 horse-power. It is equipped with a chain-grate stoker of 65.5 square feet; the gases from the fire discharge among the tubes of the heating surface located immediately above, thence down across the tubes of the second pass and finally rise on the way to the flue across the tubes of a third pass. This boiler is referred to as boiler *A*. The other boilers are of two sizes. That designated as No. 1 is 15 tubes high and 19 wide. No. 2 is 17 tubes high and 19 wide. With each the gases travel from the bottom of the back and diagonally across the tubes to the upper front end, thence back between the drums to the flue. No. 3 adjoins No. 2 in battery, and is identical with it except that the path of the gases from the back end is forward among the lower tubes of the second to the seventh rows; thence to the front end of the boiler, then back among the next five rows and finally forward among the upper five rows, where they pass between the drums to the flue. In this arrangement the gases traverse the length of the tubes three times in place of the one diagonal travel of boilers Nos. 1 and 2. The furnaces under these boilers are identical, and each is fitted with a chain-grate stoker of 72.2 square feet. The tubes in the lower row of the boiler are entirely encircled with a fire-brick tile from the front to a point back of the bridge-wall; for the remainder of the distance to within four feet of the back end the usual tile furnished by the maker of the boilers is used.

The expression "boiler efficiency" is used to designate the performance of the boiler only, not that of the combined apparatus; it implies the measure of the cooling effect produced on the hot gases, and neglects radiation and moisture in the steam.

The experimental work herein mentioned had three objects: first, to determine the relative efficiency of boiler *A* and boiler No. 1, and second, the relation between the efficiency of the same boilers and their furnaces based on combustion and heat absorption, neglecting loss of combustible in the refuse. The two relative values to be determined were—for the furnaces, the loss due to escaping hydrocarbons and incomplete combustion, and for the boilers the cooling effect produced. With Nos. 2 and 3 it was desired to determine the relative cooling effect only.

The efficiency of a boiler will be influenced by the initial or furnace temperature, and by the capacity at which it is worked. So as the horse-power increases the effect is to lower the efficiency, and as the initial temperature is lower, so is the heat transfer, and as a smaller boiler will absorb less heat than a large one, the determination of its efficiency according to some standard becomes a complicated problem. With the measure of performance of the combined boiler and furnace based on water evaporated from and at 212 degrees, a factor of evaporation has been devised to place different conditions on a common basis, but no factor, or set of factors, has as yet been devised to reduce various boiler performances to any standard of comparison. Therefore to determine the difference in efficiency between the boilers to be compared, requires in each case that the amount of heating surface, initial temperature, and amount of water evaporated, be the same; these requirements being met, it then becomes possible to discover the relative value of the cooling effect produced. These requirements were very closely met in the comparative test between boiler *A* and No. 1, and also between Nos. 2 and 3. In fact, the performance of the four boilers is so nearly on the same basis as to be suitable for comparison.

TABLE A

	BOILERS			
	BOILER *A*	No. 1	No. 2	No. 3
Square feet of water-heating surface	4000	4340	4800	4800
Square feet of steam-heating surface	383			
Horse-power, standard rating.....	400	434	480	480
Horse-power, maker's rating......	400	570	645	645
Horse-power developed	442.8	431.5	564.3	580.4
Horse-power developed above standard rating....	10.7%		17.6%	20.9%
Horse-power developed below standard rating.......		.06%		
Horse-power developed below maker's rating...........		32.1%	14.3%	11.2%
Length of travel of gases in contact with tube-heating surface, feet..	21	13	13.3	36
Temperature of escaping gases, F. degrees........................	480.2	650.5	657	469
Temperature of escaping gases above saturated steam.........	127.8	273.1	278	92
Temperature of escaping gases above air supply	407.9	580.2	582	394
Temperature of saturated steam...	352.4	377.4	379	377
Temperature of superheated steam.	455.8			
CO_2	9.22	7.93	10.7	10.3

Table *A* contains the essential data concerning the boiler trials.

Boilers *A* and No. 1 are practically of the same size, although the horse-power of the latter is rated by its maker 31.3 per cent above the former. The horse-power developed above that of No. 1 by boiler *A* is 10.76 per cent and its CO_2 is higher, but, owing to unburned volatile combustible equal to 8.79 per cent of the total combustible, the condition of combustion is less favorable for this boiler than appears from the CO_2 measurement. The conditions for these two boilers may, therefore, be considered the same, except that with *A*, the saturated steam temperature was 25 degrees lower; for this reason its final temperature has been raised that amount, so that the comparison shall be on the same basis.

In the case of boilers Nos. 2 and 3 the combustion was complete. With No. 2 the air supply and horse-power were slightly less, giving it a small advantage over No. 3.

Conditions of operation being the same, the difference of cooling effect is shown by the difference in final temperature measured above that of the air supply; this referred to the initial temperature, also above that of the air supply, determines the efficiency of the boiler.

Figure 1 illustrates the relative efficiency of the four boilers that are being considered. The initial temperature is shown through a range that covers all attainable conditions. From an inspection of the curves, it appears that the efficiencies of boilers Nos. 1 and 2 fall upon the same line, and that of *A*, which varied from the furnace temperature, is from about four per cent at 4,000 degrees to 20 per cent at 720 degrees above the efficiency of Nos. 1 and 2, while No. 3 is more efficient than that of *A*. If, however, it is assumed that Nos. 1 and 2 discharge their gases through an economizer that would reduce the temperature by 200 degrees, then the efficiency of the combined boilers and economizer will fall on the same line with that of the efficiency of No. 3 without an economizer.

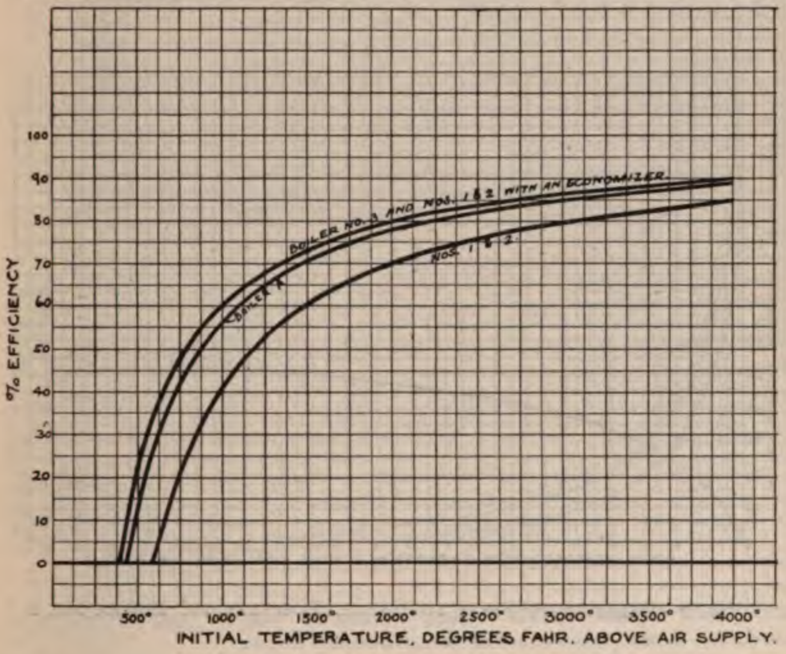


FIG. 1—EFFICIENCY CURVE OF BOILERS NOS. 1, 2 AND 3 AND BOILER *A*

The efficiency curves are based on the final temperature being constant through the full range of the initial. To what extent this is true is shown by Figure 2, which illustrates the relation between initial and final temperature, the curve being plotted from simultaneous measurements. It appears that within usual working ranges the final temperature remains quite constant. The value of the relative efficiencies from the standpoint of fuel saving is quite important. It is shown in Figure 3; the efficiency of boilers Nos. 1 and 2 being taken as the standard. The value of an efficient boiler when served by an inefficient furnace, is forcibly illustrated.

The boiler and furnace of type *A*, having no special features, are not shown, but Figure 4 is a vertical longitudinal section illustrating boilers Nos. 1, 2 and 3. The heavy arrow shows the path of the heated gases through Nos. 1 and 2. The travel in No. 3 is shown by the dotted arrows. The two baffles added in this boiler are indicated by the horizontal dotted lines; the lower of these was located so that between its ends and the back water leg there is a space of four inches left open for the full width of the boiler, to allow dust to drop down to the

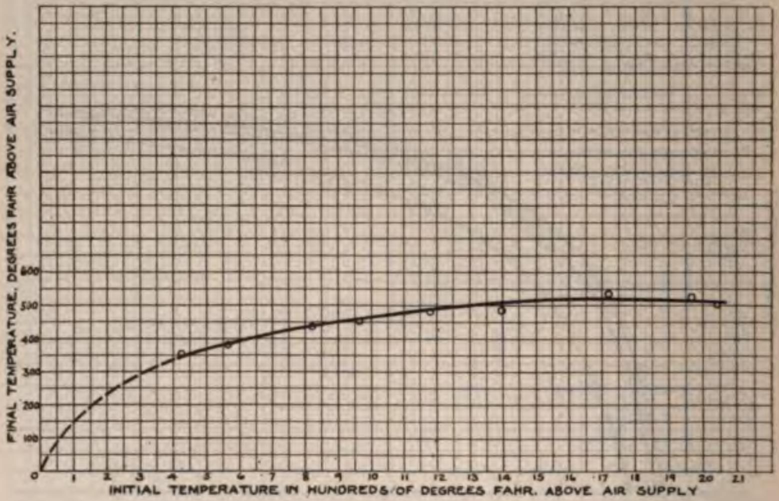


FIG. 2—RELATION OF FINAL TO INITIAL TEMPERATURE, BOILER NO. 2

chamber below. Owing to this opening, the gas travel is split into two parts, a minor portion taking the more direct and shorter route by way of this opening, as shown by one of the dotted arrows, so, in fact, the effect on the hot gases of the three passes is not entirely secured. Figure 5 illustrates a section of the tiles which encircle the lower row of tubes and provide a tile roof to the furnace extending beyond the bridge-wall. The application of these tiles was devised by Mr. W. L. Abbott for reasons that will be discussed later. Figure 6 shows the tiles which close the spaces between the lower row of tubes back of the

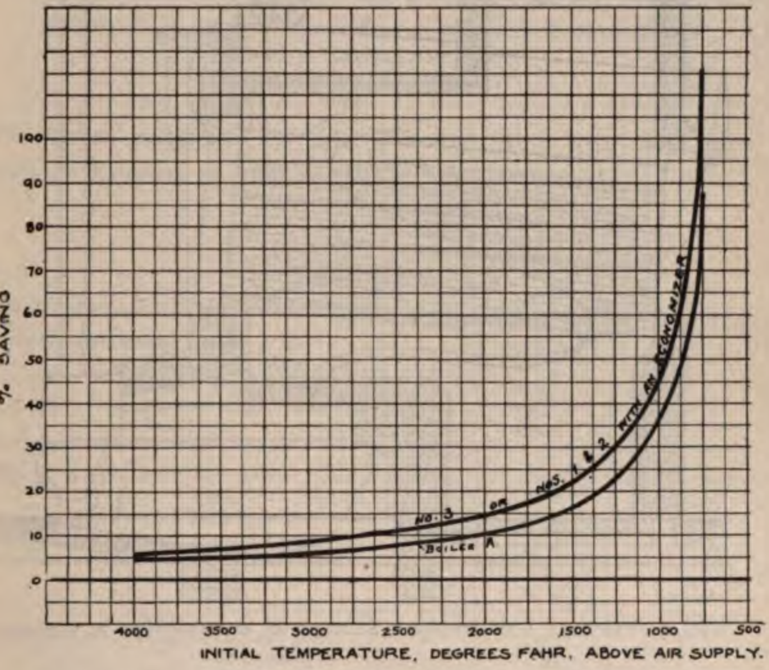


FIG. 3—SAVING MADE OVER BOILERS NOS. 1 AND 2 BY BOILER *A* AND BOILER NO. 3

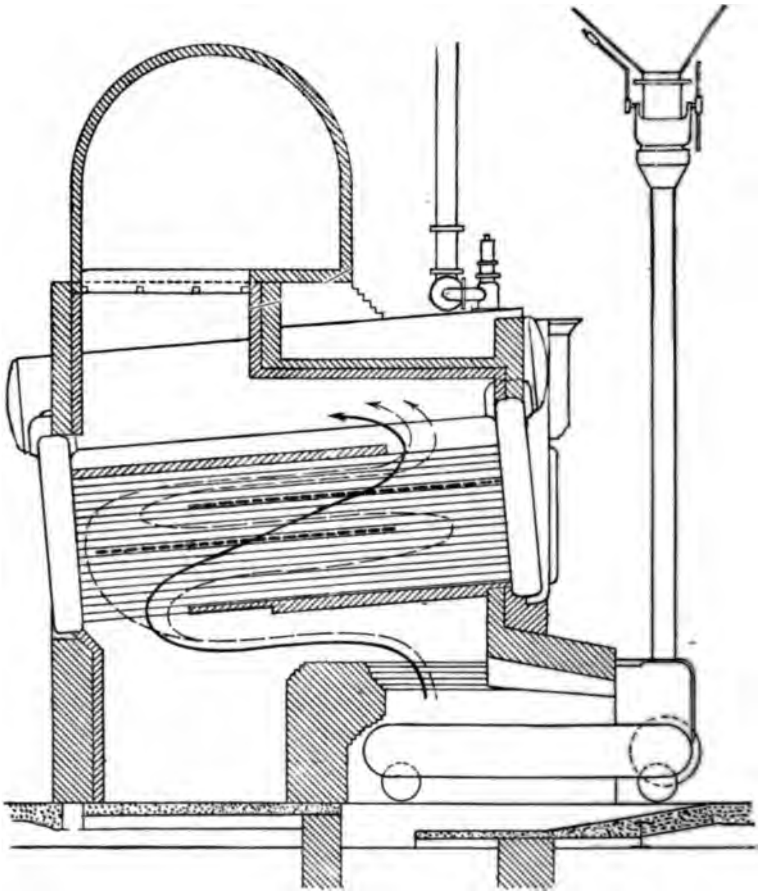


FIG. 4—VERTICAL LONGITUDINAL SECTION OF BOILERS NOS. 1, 2 AND 3

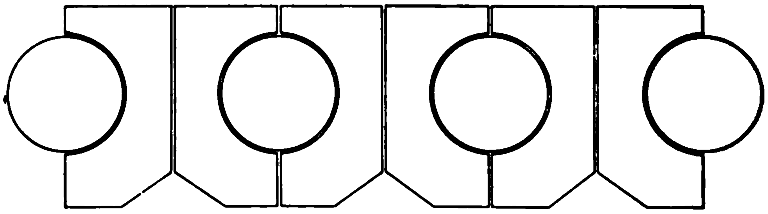


FIG. 5—SECTION OF TILES ENCIRCLING LOWER ROW OF TUBES

encircling tiles. They are those regularly supplied by the maker of the boiler, and leave the lower half of the tube exposed to the passing hot gas and are usually known as the T tile.

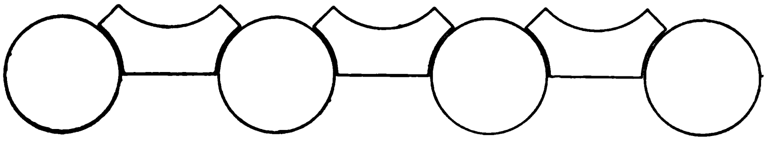


FIG. 6—TILES CLOSING SPACES BETWEEN LOWER ROW OF TUBES BACK OF ENCIRCLING TILES

TABLE B

Temperature initial	2012° F	
" at end of first pass	908° "	
" at top of second pass	680° "	
" at bottom of third pass	555° "	
" at final	480.2° "	
Drop in temperature first pass	1107° F	72.064%
" " drums	158 "	10.29%
" " superheater	70° "	4.59%
" " second pass	125° "	8.16%
" " third pass	75 "	4.896%
Total	1532° F	100.000%
Horse-power developed in first pass	321	
" " in drums	44	
" " in superheater	20	
" " in second pass	35	
" " in third pass	22	
Total	442	

Inasmuch as there is a great difference in the cooling effect between the boilers compared, it will be interesting to study the reason therefor, and also to examine the drop in temperature of the gases on the way through the heating surface. Regarding this latter phase of the matter, Table *B* gives in detail the performance illustrated in Figure 7, which is a curve of temperature drop through the surface of boiler *A* plotted from measurements taken during the trial.

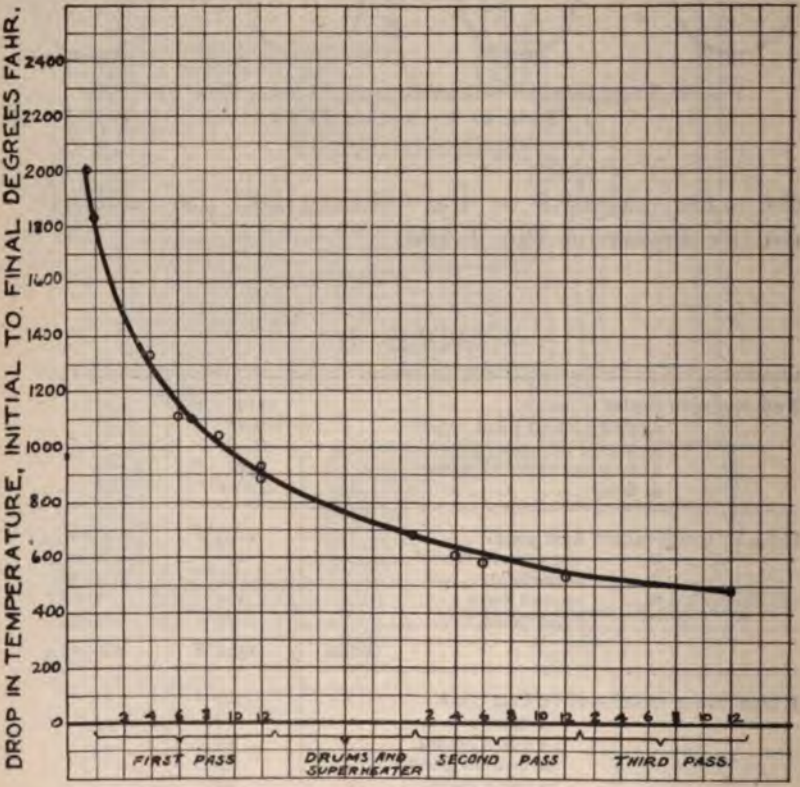


FIG. 7—DROP IN GAS TEMPERATURE IN BOILER *A* OF 400 HORSE-POWER

From this it appears that the same length of travel in the last pass gave only 6.7 per cent of the cooling effect of the first pass, illustrating the importance of the gases being in contact with the heating surface for as long a period as practicable if large cooling effect be secured. Figures 8 to 11 show measurements taken among the tubes of boiler No. 2 and also apply to No. 1. Figure 8 shows prevailing temperature among the tubes 45 inches back from the water leg, from the bottom to the top of the boiler. The measurement at the first, or lowest, stay-bolt, shows the effect of the heat from the tile roof immediately over the fire. The minimum temperature is between the second and third stay-bolts; above this it rises until at the point of escape the maximum is reached, showing that on the line of the measurements the highest temperature is at the point of exit. The drop of the ninth measurement is owing to the sudden change in the path of gas travel over the end of the baffle at the top of the boiler, which causes the hottest point to be carried back slightly more than 45 inches at this ninth stay-bolt.

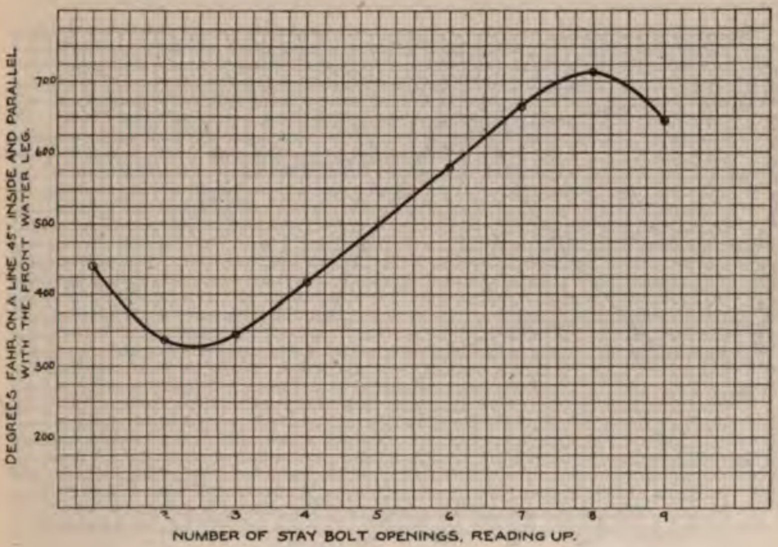


FIG. 8—BOILER No. 2

Figure 9 is a curve from measurements taken through the ninth or top stay-bolt on a horizontal line, across and beyond the path of the gases at the exit from the tubes; the highest temperature is found at a point 46.5 inches back from the inside face of the water leg. From this point in each direction there is a rapid drop as the distance proceeds.

In Figure 10 one of the curves shows the percentage of carbon dioxide in the gases on a line 30 inches inside and parallel with the front water leg of boiler No. 2 It will be observed that the measurements in the lowest part of the front of the boiler are extremely low; the first two, however, show the effect of leakage through the furnace roof. The contrast between boilers Nos. 2 and 3 in this respect is remarkable. As analysis showed the CO_2 to be low on

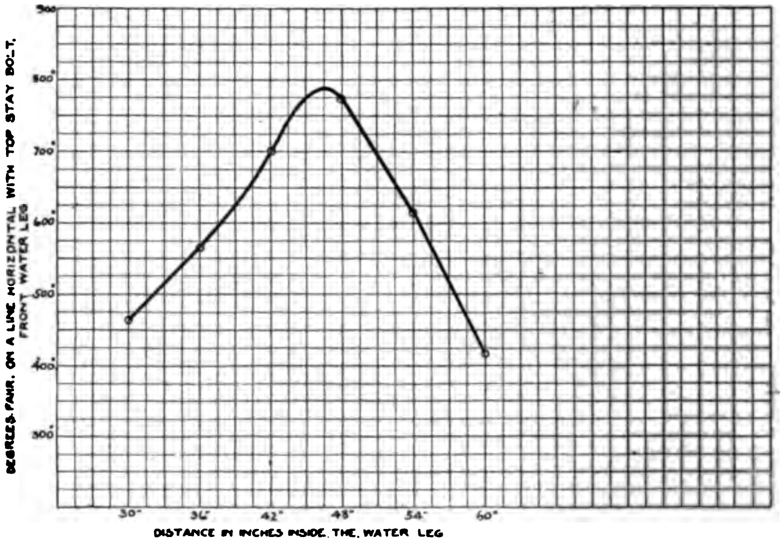


FIG. 9—BOILER No. 2

account of the presence of air, it is proof that this air must have entered by leakage, and as such leakage could not be very large it follows that the path of the gases does not extend to the front lower corner of the boiler, or along close to the front water leg. This may be considered proven by the curve of CO_2 from boiler No. 3, subject to the same leakage, but with an arrangement of baffles which caused the flow of the gases to be carried into the front lower corner and nearer to the front water leg. It is further illustrated by Figure 11, giving CO_2 measurements across the path of the gases at the exit from boiler No. 2, showing that the CO_2 increases with the distance away from the water leg. From measurements made through the back water leg of boilers Nos. 1 and 2, it is shown that a similar condition to that in the lower

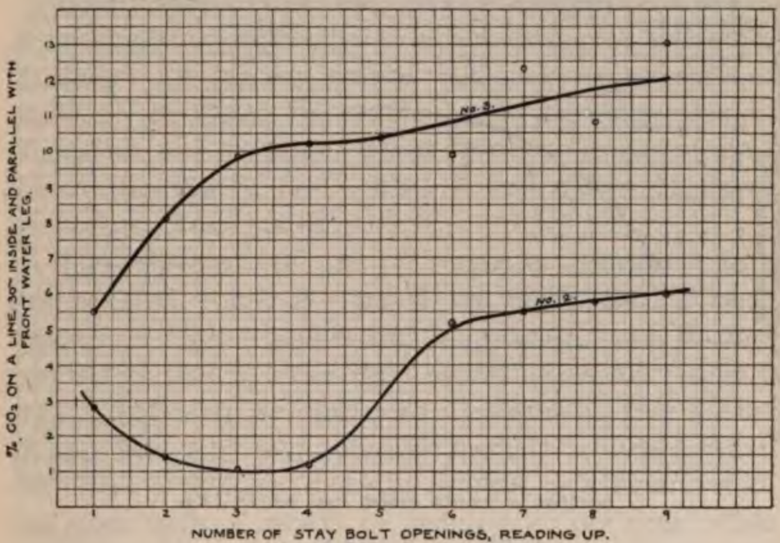


FIG. 10 - BOILERS NOS. 2 AND 3

front corner existed in the upper back corner of the tube surface, but on a reduced scale, showing that with these boilers the back upper corner performs a small amount of work and the front lower corner still less, also that the active portion of the heating surface is on a diagonal line from the lower back to the front upper corners. It shows further that the volume of the moving gas body is of decreasing magnitude as it proceeds, and that as its centre is approached the temperature is higher, so it is probable that its centre is moving at a much higher velocity than its surface. According to Figure 9 it would appear that the greater portion of gas was flowing through the space of one foot at the front end of the top baffle, and if an opening four feet long from the furnace at the lower back corner is large enough, it would follow that a space considerably less at the outlet would answer.

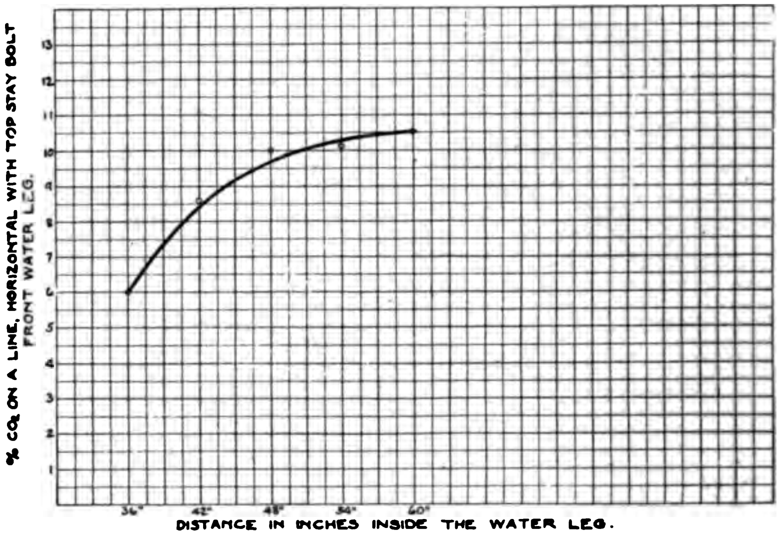


Fig. 11—Boiler No 2

As the volume of the gases decreases rapidly with drop in temperature, it is probable that boiler *A* would be improved by passing the gases across it four times in passages of properly proportioned size, not adding to the amount of heating surface, but bringing more of it into active use; because with this boiler, as with Nos. 1 and 2, the tendency is for the gases to flow in a narrow path diagonally across the tube surface of the pass.

It is apparent that the greater efficiency of boiler *A* as compared with No. 1 is not owing to difference in amount of heating surface, but to greater length of travel of the gases in contact with the same amount of surface, or, in other words, greater length of time for the transfer of heat. This is still better illustrated by boilers Nos. 2 and 3.

The efficiency of the *A* type as compared with that of Nos. 1 and 2 is based on this particular type, which is a high "double-deck" apparatus, and it does not follow that a lower type would show such superiority. This may be illustrated by assuming that boilers *A* and No. 1 be each reduced one-half in height, when the effect would be that the length of the travel of the gases with *A* would be reduced 50 per cent, while with No. 1 the reduction would amount to less than ten per cent; so, as the height is less, the efficiency of *A* drops off very much faster, and while the gain in the high No. 2 over the low No. 1 type is small, with that of *A* it is very large.

The initial temperature, or, in other words, the condition of combustion, has more effect on the efficiency of the steam-generating apparatus than has the cooling effect of the boiler. This is shown by the efficiency curves Figure 1, and if choice lay between the two, that of high initial temperature would be chosen;

but high initial temperature is always dependent on skillful manipulation of the fire, and its attainment is difficult and more or less uncertain, while the superior boiler efficiency has a fixed value not dependent on the skill of the operator, and this value increases as the initial temperature decreases. There might be some question as to whether the full value of a good furnace would always be realized, but there could be no failure to realize the value of an efficient boiler.

The most remarkable feature of this matter of boiler efficiency is that the simple addition of inexpensive baffles, with no labor cost for operation and requiring no additional room in the plant, gives results equal to an economizer requiring a large investment, considerable expense for maintenance, and a large amount of space for its installation.

The foregoing refers to the boilers only, and it is now in order to examine the furnace performance. The comparative test between *A* and No. 1 gave the following relation between the two apparatus:

	A	No. 1
1. Efficiency of combined boiler and furnace	57.83	59.12
2. " of boiler	77.69	70.12
3. Superior efficiency of boiler	7.57	
4. " efficiency of furnace		8.86

Item 1 includes all losses except that of combustible in the refuse, all other losses except hot gases and combustion being the same for each apparatus.

Item 2 is the measure of the cooling effect produced by each boiler.

Item 3 is the difference in the cooling effect produced by the two boilers.

The superiority of the furnace under boiler No. 1, Item 4, is owing to better combustion, there being a loss of 8.86 per cent with the furnace of the *A* boiler, due to escaping hydrocarbons and incomplete combustion, the air supply being considered the same in each case. The reason for the difference in combustion with these two furnaces will be understood when each is examined in detail. The furnace under the numbered boilers will hereafter be referred to as the tile-roof furnace, and the other as the *A* furnace; the former is shown in elevation by Figure 4; the roof is made with tiles shown by Figures 5 and 6. The distance from the coal gate at the front of the furnace to the end of this tile roof is 16 feet, a distance through which the gases must travel before coming in contact with the boiler surface except in the lower half of the bottom row of tubes, which for a distance of about four feet back of the bridge-wall are exposed as shown by Figure 6, there being a distance of travel of 12 feet with no cooling effect, except that of radiation from the exterior furnace walls and through the tile roof. During the interval of time that the gases are moving through this distance of 16 feet their mixture is proceeding, so that before they have reached a point among the tubes where the temperature has dropped to a point below which union will be effected, the mixture is completed; or, as more generally understood, complete combustion is effected.

With the *A* furnace the gases from the fire rise immediately and pass among the tubes of the boiler. There being not to exceed three feet in distance for the gases to travel before the tubes of the boiler are reached, the temperature soon drops to a point at which chemical union does not take place; the result is an escape of unoxidized combustible in the form of hydrocarbons, carbon monoxide and free carbon.

Figure 12 is a reproduction of a photograph of a plant containing the tile-roof furnaces described, and also the *A* furnaces set under the *A* type of boilers. This was taken at a time when the plant was working at about its full rated capacity. The four tall chimneys serve 24 boilers of the type designated as Nos. 1 to 3, fitted with the tile-roof furnace, and equipped with chain-grate stokers of the *A* type, with a total grate area of 1,732 square feet, and with a total of 104,980 square feet of boiler-heating surface. The

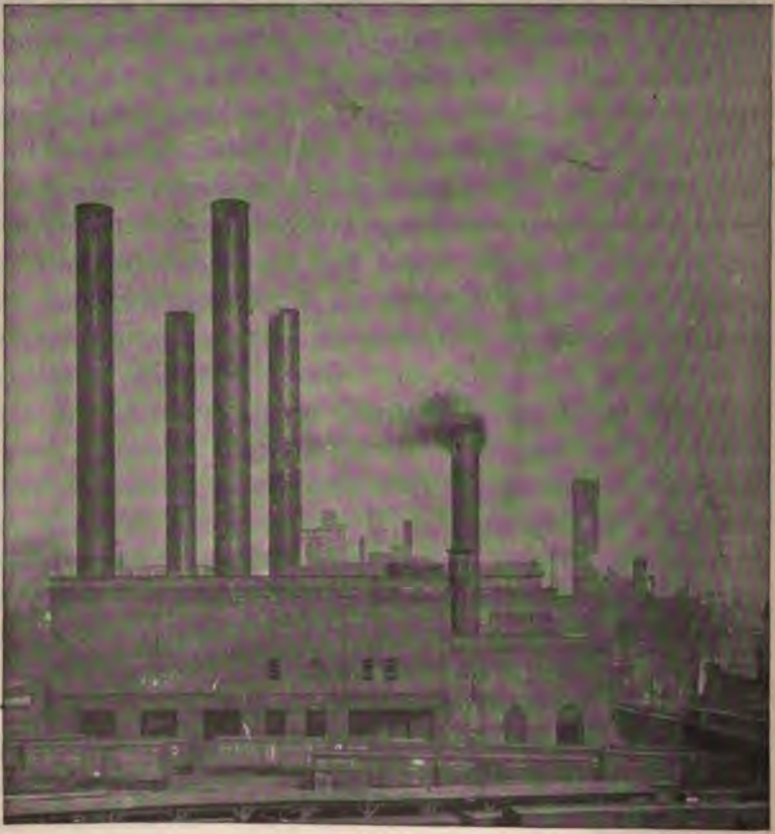


FIG. 12—PLANT CONTAINING THE TILE-ROOF FURNACES, ALSO *A* FURNACES SET UNDER *A* TYPE OF BOILERS

draught over the fire, measured in inches of water, ranges from 0.15 to 0.45. The shorter chimney on the right serves four *A* type boilers of a total heating surface of 20,000 square feet, equipped with chain-grate stokers having a total grate area of 306 square feet; the draught over the fire ranges from 0.20 to 0.25 in inches of water. The coal being burned at the time this photograph was taken, contains combustible matter that will average about 59.7 per cent fixed carbon and 40.3 volatile matter. It has a heating power of an average of 13,600 B. T. U. per pound, and is what is considered the poorest coal that is mined in Illinois on an important scale; it is, however, the coal that gives the most heat from a money value in the Chicago market, and, like all Illinois coals, will make much smoke when conditions are favorable. The appearance of the four chimneys which serve the tile-roof furnaces, compared with that of the others serving the *A* type, is evidence of the difference in action of the two kinds of furnaces.

The theory of the action of the tile-roof furnace may be given as follows: The coal entering at the front of the furnace has its volatile matter rapidly distilled in the form of a hydrocarbon gas in excess of the air supply at the front of the fire, and flowing back meets a larger air supply from the back of the fire, where the fuel bed is thinner. With this it mixes, the excess of air from the back satisfying the deficiency at the front; and being thoroughly mixed in the chamber below the tile roof, it becomes, strictly speaking, a product of combustion at high temperature, which carries its heat from the furnace to the boiler. Assuming that the action of this furnace is as described, it would appear possible to obtain complete combustion with no air in excess; the indications are that this is possible. With one of these furnaces carefully worked, and with the draught pressure at a certain determined intensity, it was possible to maintain an average as high as 17 per cent CO_2, and for a few short intervals obtain as high as 19 according to the econometer connected to the furnace. There was no opportunity to test this condition with analysis, however, owing to the short duration of the intervals, but the econometer checked very closely with analysis at lower ranges. With the extremely small air supplies as given here, if the feed of coal was increased, it was accompanied by a raise in CO_2 to the apparent theoretical maximum, after which it fell, owing, presumably, to carbon being oxidized to carbon monoxide, but there appeared to be no tendency for carbon to be set free.

With the *A* type chain-grate stoker and boiler, or similar boilers and furnaces, the gas distilled at the front of the fire flows directly among the tubes, and results in loss by unburned hydrocarbons and free carbon, the latter making smoke, while the large excess of air from the thinner back end of the fire also flows directly among the tubes, but at a different point, and there is but poor mixture. With such furnace, the smoke and loss of hydrocarbons will drop off with increased excess of air, owing to a stronger draught; but the loss from this increased excess of air is greater than the combustion gain, therefore best efficiencies are to be obtained with the smoky condition.

The above, concerning the three types of boilers and two kinds of furnaces under discussion, may be followed by an examination, as far as present knowledge will allow, of the single type of stoker that is to be considered. This is the chain-grate, and the one that is the nearest approach to an automatic machine; but in practice it is decidedly unsatisfactory so far as efficiency is concerned. The best performance secured with these stokers in the tile-roof furnace boilers is as follows:

	Example 1	Example 2
Efficiency	72.0	69.8
Pounds of water evaporated per hour per square foot of heating surface	4.1	6.07
Horse-power per square foot of grate	6.13	11.6

From these examples the efficiency has ranged down to 40 per cent and capacity in proportion. The size of the coal used has an important effect on capacity—all other conditions being the same—and may affect the result as much as 60 to 80 per cent. The greatest fault thus far recognized in chain-grate stokers is the air leakage into the furnace at the back end of the grate. This and loss of combustible in the refuse are its major faults. With the grate as usually made and installed, an effort to prevent fuel being discharged over the back end by running short fires, is accompanied by an increase of the excess of air that often overbalances the fuel saving.

The entrance of air at the back end of the grate is, strictly speaking, a leakage; its entrance is by way of openings at the side of the stoker, between the top and bottom chain and under the traveling grate, and into the furnace by way of the opening between the bridge-wall and the end of the grate. For this leakage at the back of the fire there are two remedies; one is to make the opening for the discharge of the refuse only large enough to allow the ash to pass out, and keep the end of the fire in contact with the bridge-wall. This opening may be restricted by building the brick bridge-wall the required distance above the grate, or by building into the point of the wall a metal box or pipe through which water circulates for the purpose of keeping it cool. The disadvantages of the brick wall are that the clinker readily adheres and makes trouble, and that the life of the brick at the lower edge is very short, requiring frequent and expensive renewal. The size of the opening is a matter that is necessarily unsatisfactory, because the amount of ash in the coal will differ and the opening must be large enough to accommodate the largest amount, consequently being too large when ash is low. The performance designated as example No. 1 was obtained with the brick wall described, and owing to an extremely large amount of ash in the coal the effect was to close the opening at the end of the grate largely with ash rather than with fuel, resulting in a comparatively small loss to the ash pit. Of these two means for keeping the air from leaking into the furnace by maintaining a joint between the end of the fire and the bridge-wall, the water-back is the most satisfactory.

The other method of stopping air leakage at the end of the fire consists in closing the openings at the sides of the stoker frames, between the bottom chain and the floor under the stoker, and between the upper and lower chains. With this scheme the air leakage is avoided without keeping the fire against the bridge-wall. It was with this method that the performance designated as example No. 2 was obtained; the large capacity was owing to the use of washed coal from the Wilmington district of Illinois. At the present time the best means to offer for the remedy of the faults at the back end of the fire is to seal off the leaks as mentioned in the second method, and the use of the water-back located as close to the grate as practicable. The latter performs an important office, inasmuch as it is an insurance against carelessness in running the fires over the back end of the grate.

The foregoing has treated only of the excess of air coming from the back end of the grate, but it does not entirely cover the subject of excess of air. With the furnace of the *A* type, 12 per cent CO_2 is about the maximum under any condition. This is also true of the tile-roof furnace unless the fire is so operated that a considerable excess of volatile combustible is evolved at the front end of the fire and mixed with the excessive air from the thin fire at the back. But the evolution of an excess of volatile combustible requires either a thick fuel bed or a low draught, and it appears that the thickness of fuel bed and strength of draught are features of importance.

With chain grates as generally installed and operated, all other conditions being the same, a reduction in the draught over the fire results in increased efficiency and reduced capacity. On the other hand, an increase in draught over the fire increases the capacity but reduces the efficiency. In the plant mentioned as having the tile-roof furnaces, draughts over the fire range from 0.15 to 0.45 in inches of water, but the attainable depth of fire, height of coal in the hopper and speed at which the grate travels, are the same for each strength of draught. It is entirely reasonable to assume that if 0.15 is strong enough, 0.45 is too strong; likewise that if 0.45 is right 0.15 is too low; and it is apparent that the dimensions of the stokers and the various draughts are not in proportion to each other. In this plant the high efficiencies are always obtainable with the lowest draughts, and the highest capacities with the strongest draughts.

It is the general tendency to seek a strong draught over the fire with chain-grate stokers, and for this purpose induced mechanical draught apparatus and tall chimneys are employed; but suction draughts may be so strong as to cause such an excess of air to flow through the coal in the hopper as to prevent the fuel from igniting. It is possible that a moderate suction above and a pressure above atmosphere under the fire will give the most satisfactory results when large capacities are required.

Loss of combustible in the refuse with chain-grate stokers has been observed as low as one per cent. With the tile-roof furnace, complete combustion with little or no excess of air has been secured, and if such desirable furnace conditions are combined with the performance of boiler No. 3, it will make an important improvement over the best prevailing practice. It is probable that this is the most efficient boiler of which there is any record. About the highest efficiency reported is that of a Thornycroft boiler by Professor Kennedy, showing 86.8 per cent of the heat absorbed when evaporating 1.24 pounds of water per square foot of heating surface per hour with a condition of combustion about the same as that with No. 3; under these conditions the gases left at 41 degrees Fahrenheit above steam temperature. With, however, an evaporation of 3.2 pounds of water per square foot of heating surface and a somewhat better combustion, the gases left at 165 degrees Fahrenheit above steam temperature. In the case of boiler No. 3 the gases left at 92 degrees above steam temperature when evaporating 4.17 pounds of water per square foot of heating surface. No. 3 is a more efficient boiler than *A*, but owing to its design, there is no favorable location for a superheater. With the *A* type, the design affords an excellent location, which is sufficiently removed from the excessive furnace temperature, and at a point where it is high enough to ensure the desired effect.

There is one feature of the tile-roof furnace previously mentioned, which is of considerable importance. It is the protection afforded to the lower row of tubes of the boilers designated as Nos. 1 to 3. It has been the maker's practice to use the tiles shown by Figure 6. This leaves one-half of the bottom row of tubes exposed to the full furnace action; it does not matter that there are many hundreds of feet of surface in the boiler above, because the gases do not come in contact with this surface until after leaving the furnace. As with an economizer, the boiler is heated first. Applying this illustration to the surface exposed to the fire, the 110 square feet over the furnace may be assumed to be the boiler surface. This would mean that there are about 1.5 square feet of heating surface per square foot of grate; the result is that the tubes in the bottom row become blistered, bent out of line and fail, owing probably to the area of the tube not affording sufficient water supply. But with the tiles in place, the tubes in the lower row remain as straight and in as good condition as those in the uppermost row.

In concluding this paper, it will be interesting to make a comparison of the principal losses that occur with boilers and furnaces. For this purpose Figures 13 and 14 have been prepared. These diagrams are designed to be pictorial illustrations showing the relations that these individual losses bear to each other, and would be best shown by one diagram if it were not for the complication of a large number of lines in one figure. For this reason the boiler loss is shown in Figure 13 and that of the furnace in Figure 14; with the former the performance of boiler No. 3 is selected to represent the loss owing to decreasing cooling effect with a very efficient boiler, and No. 2 for a much less efficient boiler. The zero of loss is taken at the steam temperature, because below this point no further cooling of the gases can take place; the range of capacity is carried up to the evaporation of 12 pounds of water per square foot of heating surface per hour, and the location of the lines is governed by the performance of the two boilers in the tests before mentioned. These two losses are represented as straight lines, which is not entirely correct, because as such they will intersect the line of 100-per-cent loss if capacity be carried far enough, but a boiler could never be driven

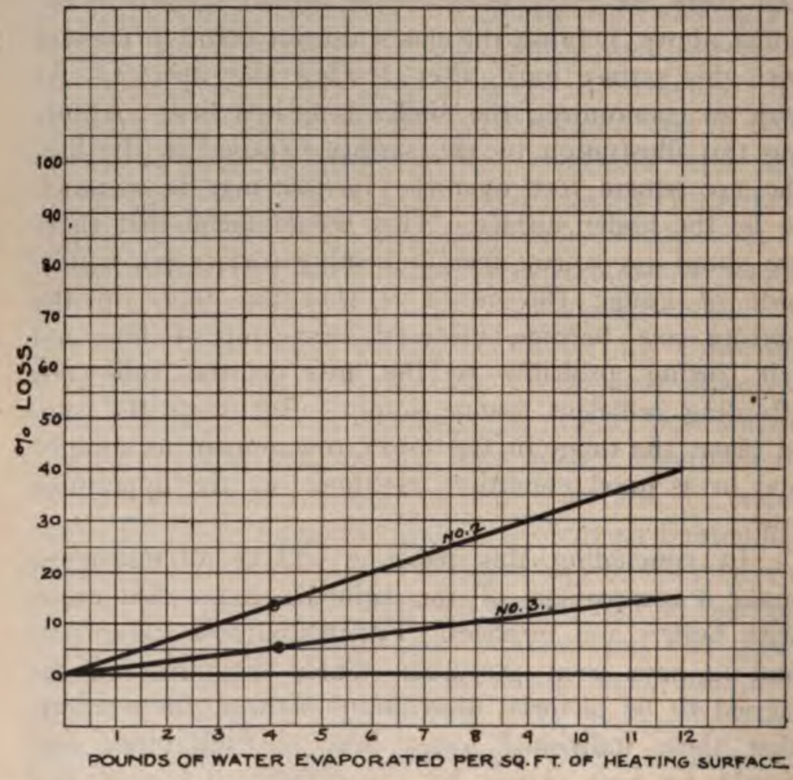


FIG. 15—PRINCIPAL LOSS OWING TO BOILERS. DIFFERENT CAPACITIES. AIR IN EXCESS 85 PER CENT

so hard that its efficiency would become zero. The representation by straight lines is sufficiently correct, however, for the purpose in hand.

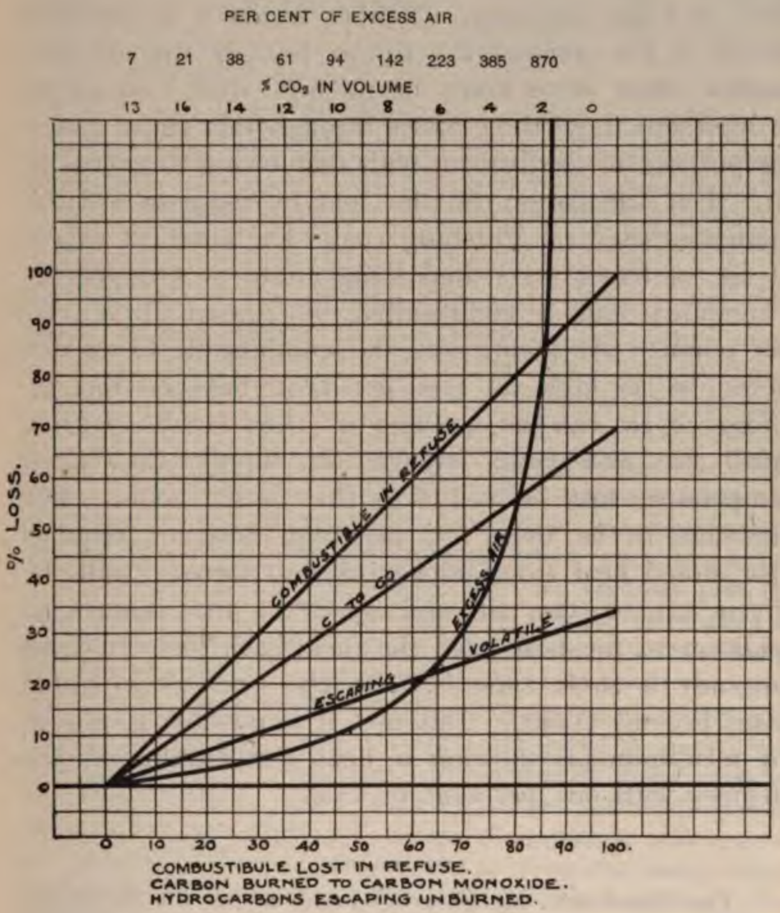


FIG 14—PRINCIPAL FURNACE LOSSES

Referring to Figure 14, the losses owing to combustible in the refuse, carbon burned to carbon monoxide, and to escaping volatile combustible, are each carried to the theoretical maximum. It is, of course, impossible that all of the volatile matter could escape unburned; or that all of the carbon could be oxidized to carbon monoxide, as this is unattainable even in a gas producer. Neither would it be possible for all of the combustible to be lost in the ash pit, because then there could be no fire. But it is useful to represent these three losses through this entire range for purpose of comparison with that owing to excess of air. The calculation of the loss of escaping volatile matter is based on Pittsburg coal. The curve of excess of air is based on a final temperature of 550 degrees Fahrenheit and a combustible of 14,000 B. T. U. per pound. As mentioned, the combustible losses can never be as high as 100 per cent, but the loss by excess of air can be as high as that, because with a small fire and large enough air supply, the initial temperature may be as low as that of the boiler. For this loss to be over 100 per cent, however, requires that stored heat from brick-work and furnace walls be given up to the air and gases in the furnace in addition to the heat from the fuel; such loss can exist for only a short time because the brick-work would soon become cooled. But that it is possible is proven by measurements showing a final temperature of 520 degrees with one per cent of CO_2.

DISCUSSION

The President: Mr. Bement's paper is open for discussion. We shall be glad to hear from any one. You are all interested in efficiencies of all kinds, and this is an important subject. There surely must be some one of our members who has something special to say upon it.

Mr. W. L. Abbott (Chicago): This question of boiler and furnace efficiency has been my hobby for several years. I read a paper in this room three years ago before this association, the principal part of which referred to work in the boiler-room.

At that time I was convinced that that was the important end of the power station, and the further I go into the matter, the more am I convinced that it is the beginning, if not the end, of our success and of our trouble. I think Mr. Bement's paper brings out very strongly one important fact, which is that we are often ignorant of the fact that a large proportion of the heating surface of the boiler is lying dormant and that the remaining portion of the boiler, which is in service, is being overworked to such an extent that we get comparatively poor efficiency from the boiler in comparison with what we should get if the boiler were so arranged that all the heating surface was brought into equal use. I will state the proposition in another way: If all the heating surface of the boiler were brought into use, we could use the boiler to a much greater capacity with the same efficiency than we ordinarily do. The following is an old illustration with the common tubular boiler: Take a stick of dry pine wood, stand it up inside the smoke extension in front of the centre row of tubes, and let it stay there for a short time; then take it out and examine it and you will find that portion of the stick that was opposite to the upper row of tubes is much charred, while the portion near the bottom row of tubes is scarcely charred at all; showing that the gases that came through the upper row of tubes were hotter than those in the bottom tubes; this also signifies that the gases traveled through the upper row of tubes faster than at the bottom, and on that account were not cooled as much as at the bottom. With a proper distribution of the draft the gases would be made to travel through all the tubes uniformly, and the average temperature of the front end would be much lower than it usually is. The same thing applies to some types of water-tube boilers. Where these things are not carefully considered and guarded against, the gases are sure to take a short cut through the boiler in some way or other and leave "dead pockets." This matter is clearly brought out, I believe, in the full text of the paper that Mr. Bement read only in abstract.

The reference to the reduction of the amount of smoke is also a very vital one to those who are operating stations with soft coal in large cities. There are innumerable methods for preventing smoke, and some of them sometimes work in some places while, for reasons for which no one can account, they do not work in other places. The method that he has described would, I think, be a panacea for this almost universal complaint if it could be applied as it is in the case described by him. These stacks shown in the half-tone are taken from the Chicago Edison Company's plant, and we have during the past winter burned coal at the rate of three-quarters of a ton a minute without producing the slightest cloud of smoke. There is no special care taken in firing to prevent smoke, but from the construction of the furnace it will take all the coal you can give it and burn it completely and no smoke whatever has been produced by any method that any fireman has yet tried. The other stack described—the stack from which smoke is coming—is from a furnace with a different construction; and I think it is the result that will inevitably be produced when coal is burned in a furnace where the flames come in contact with the cold boiler surface before the combustion is complete.

These two points, I think, are the principal points of the paper; at least they are the points that impressed me most, and they are well worthy of consideration by those whose coal bills are unsatisfactorily large—and I do not know of any company whose coal bills are not so—and also those who are troubled with smoky chimneys.

MR. LIEB: I would ask the author of the paper whether the curves on pages 196 and 197, giving the efficiency of the furnace and the evaporation per square foot of heating surface, are plotted from a number of observations at the different rates of evaporation? As the paper was read in abstract, I was unable to follow the reference to the diagrams. From certain tests made, not with soft coal, but with anthracite, and made at different rates of combustion and different rates of evaporation, the curves did not actually follow the straight line as indicated in the diagrams on pages 196 and 197. In fact, the paper refers to combustion in furnaces for soft coal alone, and the conclusions, perhaps, are not in every case applicable to combustion with hard coal. At the present time the conditions in many of the eastern cities are such that the best economic results, that is, the greatest quantity of water evaporated per dollar, are not obtained from the use of soft coal. The most economical forms of fuel in many of the eastern cities at the present time are smaller steam sizes of anthracite coal, No. 2 and No. 3 buckwheat, from which a greater amount of evaporation per dollar can be obtained than with soft coal, even taking into consideration the larger amount of grate surface necessary to handle these small sizes of anthracite coal. The New York Edison

Company, in its Waterside station, has some of the furnaces equipped with Roney stokers on which soft coal or a mixture is used, and other furnaces with flat grates on which No. 2 or No. 3 buckwheat is used. The grate surface required in the case of No. 3 buckwheat is greater than in the case of the furnaces using bituminous coal, and the commercial efficiency, if you may so call it, is also greater, even with hand firing; that is, more pounds of water are evaporated per dollar with the No. 3 buckwheat, including repairs and maintenance charges on the furnaces and grates.

Some years ago, in considering rates of evaporation and furnace efficiencies for hard-coal conditions only, a calculation was made to determine to what extent it was economical to force boilers using the steam sizes of hard coal. Under the conditions prevailing in New York city at that time—some three or four years ago—a considerable percentage of the total capacity of the plant was required but a small number of hours per year; approximately 25 per cent of the total capacity of the plant was required for operating less than 100 hours in the year. In that case, it was commercially economical, in order to obtain the extra capacity during these short periods, to sacrifice considerably in economy. It was found economical to force the boilers on these peak conditions, lasting such a small number of hours per year, increasing the evaporation to from 80 per cent to 100 per cent above that required to obtain the boiler rating, requiring rates of combustion of 30, 35 and 40 pounds of coal per square foot of grate per hour by putting forced draft under the grates of one and a half to two inches of air pressure. Under these conditions there was no unusual or excessive depreciation in the boilers or furnaces, or in the tubes, and it was felt that the commercial efficiency of the boiler under these conditions was such as to make it economical to do a considerable amount of forcing. I would ask Mr. Bement, in conclusion, if the curves referred to are plotted from actual observation?

MR. BEMENT: The two curves or lines in Figure 13 are based on the two points shown, which are from the tests of boilers numbers two and three. These curves refer to decreasing cooling effect of the boilers, caused by the increased capacity, and attention should be directed to the fact that they refer to boiler efficiency only, and not to efficiency of combined boiler and furnace. The curve mentioned by Mr. Lieb as having been plotted from his experiments, shows performance of combined apparatus, as I understand him, which is different from that shown in Figure 13. Referring to the curves in this figure, the text says that as straight lines they are not correct, because as such they would intersect the line of 100-per-cent loss if the capacity be carried far enough, but a boiler could never be driven so hard that its efficiency would become zero. How much they fail to conform, actually, to the straight line, I do not know, because of the difficulty or impossibility of carrying capacity sufficiently high to show where the curve should begin to drop to a noticeable extent from points based on the evaporation of from three to seven pounds of water per square foot per hour. I could not get variation enough in these ranges to justify a departure from the straight line. These lines, of course, drop off so that they never reach the line of 100-per-cent loss, and this drop probably begins at zero and proceeds in a gradually increasing measure as capacity increases. These lines are sufficiently correct for the purpose for which they were made, which is to compare with those of Figure 14, and in this way show the magnitude of the boiler loss as compared with the furnace losses. It is to be understood that these two diagrams are designed to be pictures showing the principal individual losses in their relation to each other.

The most economical capacity for a boiler will be secured when the combustion is complete and the air supply utilized to the greatest possible extent. This is shown by Figures 13 and 14; the loss shown in Figure 13 may be well afforded if it results in the reduction of such a serious loss as that of excess of air shown in Figure 14. Owing to bituminous coal burning very fast, it requires a large supply to avoid large excess of air. This results in a large fire and capacity for the condition of greatest efficiency. Boiler makers have often been able to get large capacity with bituminous coal, but when installing the same apparatus for anthracite with the hope of securing like capacity, have not been able to make it go.

MR. C. G. Y. KING (Chicago): As an adjunct to boiler and furnace efficiencies and as a means for eating the waste heat in its passage through the stack, it is common in some places to install an economizer. If there is any gentleman present who can give an idea of the value of an economizer, as regards its investment and the products derived from it, I should like to hear it. I have discussed the question with many people and can never get a satisfactory solution of it. On page 177, Mr. Bement says that the application of the tiles referred to was devised by Mr. W. L. Abbott. Some years ago I got an idea into my head that these tiles would be useful, but before proceeding to carry it out I had a search made in the Patent Office and found that a firm in Chicago had made application for a patent some 18 months previously. Their drawings coincided quite closely with a patent issued in Great Britain 12 years before.

MR. ALEX DOW (Detroit): I think it is in order, in this connection, to accentuate the fact that Mr. Lieb found in New York that a furnace can not be designed nor a stoker selected that will give equal efficiency with coals radically different in their chemical properties, as are anthracite and bituminous coals. I think it is also in order to accentuate the fact that there are many different kinds of bituminous coal. I do not think I say too much when I say that a furnace to be designed with a view to the highest efficiency must, as the very first condition, have prescribed for it the kind of fuel it is to burn. You can not even exchange between two grades of bituminous coal and get similarly good results. The free-burning coals, such as were used in the economy tests reported by Mr. Bement—Wilmington coal and others of that class—behave differently in a furnace from the West Virginia coking coal. They require different proportions of combustion chamber and different handling on the grates. It is recognized in hand firing that the coking coals must be worked on the grates. It is also recognized that these free-burning coals must not be worked too much, but fed to a definite thickness and allowed to flame freely. Coals with high carbon can be burned with a comparatively small combustion chamber, because the combining of the carbon with the oxygen is completed promptly; but long-flaming coals require high-combustion chambers. One of the advantages that I recognized at once as pertaining to the tile-furnace construction is that it provides a hot, long and large combustion chamber for the free-burning coal burned in Chicago. There would be an improvement, in addition to the other advantages, simply from cutting off the cooling effect of these tubes by covering them with the tiles. I am frequently in receipt of letters from central-station men asking what is my experience with such and such a stoker, and asking me if I can recommend it to them. I have for many years taken special pains to say that I can recommend it if the fuel that they use has the qualities suited to the stoker. The Roney stoker has a mechanical advantage in that it will handle any class of coal; but it can not be designed to be equally efficient with the eastern bituminous coal having a large proportion of fixed carbon and the western coal with a high proportion of volatile gases and with a tendency to slag. The chain grate is probably the best combination that could have been made with the Wilmington and other Illinois fuel. It does not follow that the chain grate is the best stoker for a coking coal; nor does it follow, because of the Chicago Edison experience, that the chain grates should be adopted all over the country. Our experience in a district like Detroit, which is on the border between the coking-coal supply and the free-burning western coal, and which is sometimes more cheaply supplied from one district and sometimes from another, is that the stokers that last year were not satisfactory, and of which we declined to purchase more, are this year the most effective, because of the change of coal supply. I think that point appears strongly between the lines of the paper, and should be made clear to every member.

MR. LIEB: Do I understand Mr. Dow to say that he has been able to burn No. 2 or No. 3 buckwheat anthracite with a high degree of success on the Roney stoker?

MR. DOW: I do not say so. Some stokers will lie down if you feed them small buckwheat. The Roney stoker will make some kind of effort to burn it. There is a possibility of selecting a stoker that will burn to some extent, and possibly to some degree of efficiency, any kind of fuel you give it, but that versatility in burning fuel is obtained at a sacrifice of efficiency.

MR. LIEB: I do not think you can get any commercial results with No. 3 buckwheat.

MR. DOW: It is worth $5.00 a ton in our city and we do not attempt it.

MR. LIEB: The small sizes are extremely difficult to burn on a Roney stoker. I should like to hear the experience of any member who is able to burn No. 2 or No. 3 buckwheat on a Roney stoker with any degree of success.

MR. BEMENT: With reference to the application of the tiles to the furnace in question, the paper intended to say that Mr. Abbott devised the application in the particular case referred to. I have been told of similar tiles being used 15 years ago.

THE PRESIDENT: We will now take up the paper by Mr. John S. Peck, of Pittsburg, on "Standard Transformer Voltages."

Mr. Peck read the paper, as follows:

STANDARD TRANSFORMER VOLTAGES

That the advantages resulting from the use of standard apparatus are appreciated by both manufacturer and user, is shown by the continual efforts of the manufacturer to standardize his apparatus, and by a decreasing tendency on the part of the customer to call for special apparatus. The manufacturer of electrical apparatus has been handicapped in his efforts toward standardization by the rapid development of the electrical industry, which has demanded modifications in old lines of apparatus to meet changing conditions, and the design and manufacture of new lines to meet new conditions.

With the older lines of apparatus, such as low-voltage generators and motors, and transformers for supplying motors and light, certain sizes and voltages have become generally recognized as standards, but in the case of transformers for high-voltage, long-distance transmission, the voltage requirements are still in a more or less chaotic condition, and even for low-voltage transformers there are many customers who demand voltages just far enough from those usually required to necessitate new designs, new windings, and so forth.

In the early days of long-distance transmission, certain transformer capacities were selected as standard; but it was thought impossible to fix upon standard voltages for this service, as different voltages were required for raising and lowering transformers in order to compensate for line drop, and as no two lines had exactly the same length, and therefore the same drop, the same voltage was never required for two different plants. No standards had been proposed by the manufacturer, so every customer or consulting engineer was at liberty to specify voltages to suit his own conditions without regard to those elsewhere in use. For this reason large numbers of transformers were built which, though of the same size and same nominal voltage, were just far enough apart in voltage to be non-interchangeable.

In looking over a large number of transformer specifications, with a view to standardization, it was found that an allowance of more than 10 per cent for line drop was seldom necessary; also that there was a tendency among operators to specify certain nominal voltages; for example, 10,000, 15,000, 20,000, and so on. It was therefore believed that if certain nominal voltages were wisely selected, and provision made in the transformer for varying them over a range of approximately 10 per cent, standard voltages could be adopted that would fit practically all the conditions of service. The Westinghouse Company therefore decided upon the following plan: For standards, those voltages recommended by the American Institute of Electrical Engineers were chosen, with such additions as were frequently demanded in commercial work. For varying these voltages over the desired range, the plan of bringing out taps from the winding was adopted. In the table, page 207, are given the voltages that have been adopted as standard, as well as the variations that may be obtained. It will be noted that in all cases a value of five per cent below normal, and two values, one five per cent and one 10 per cent above normal, may be obtained. There is thus obtainable from any transformer a total range of 15 per cent, which is found ample for almost every condition of service.

In Figure 1 is shown diagrammatically a (10,000-volt) transformer winding with two taps brought out. The connections for the different voltages are clearly shown. This is the standard arrangement for all high-voltage transformers.

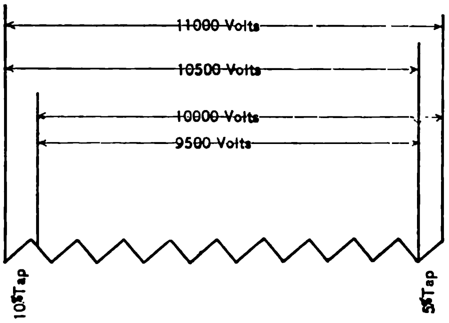


Fig. 1—High-Tension Winding 10,000-Volt Transformer. This is the Standard Arrangement for All High-Voltage Windings

STANDARD HIGH-TENSION TRANSFORMER VOLTAGES

Ten Per Cent Above Normal	Five Per Cent Above Normal	Normal	Five Per Cent Below Normal
2,200	2,100	2,000	1,900
3,300	3,150	3,000	2,850
5,500	5,250	5,000	4,750
6,600	6,300	6,000	5,700
11,000	10,500	10,000	9,500
16,500	15,750	15,000	14,250
22,000	21,000	20,000	19,000
33,000	31,500	30,000	28,500
44,000	42,000	40,000	38,000
55,000	52,500	50,000	47,500
66,000	63,000	60,000	57,000

It is frequently necessary to design the high-tension winding of transformers for series-multiple connections, the multiple connection giving one-half the voltage of the series connection. In such cases it is obviously more difficult to obtain the same range of voltage for each connection that is obtainable when a series connection alone is required. Where this series-multiple connection is demanded, the plan has been adopted of bringing out a tap from each half of the winding, so that five per cent of the total winding is included between each tap and the outside terminal. With this arrangement the multiple connection gives a voltage 10 per cent in excess of the normal; and the series connection, two voltages, one five per cent and the other 10 per cent in excess of the normal. The method of arranging the winding for these voltages is shown in Figure 2.

Where the three-phase, two-phase connection is to be provided, each additional voltage means a large increase in the number of taps brought out, and therefore complication of terminal block. Where this connection is required, the transformer is provided with taps for increasing the normal voltage by only 10 per cent.

It is obvious that there may be other special requirements where the standard arrangements as outlined above can not be employed, but in the great majority of cases it is found that the arrangements proposed are eminently satisfactory.

STANDARD LOW-TENSION VOLTAGES

The low-tension voltage of a transformer is determined by the character of the load that it is to supply, or in the case of a step-up transformer, by the voltage of the generator from which it is supplied. It is obvious that to meet all conditions of service, a large number of voltages will be required. Low-tension voltages may, however, be divided into a few fairly well-defined classes, thus: 100, 200 and 400 volts for supplying lights and motors, 1,000 and 2,000 volts for general distribution, and such voltages as are demanded for different classes of rotary converter work.

To standardize low-tension voltages, the same plan was adopted as for the high-tension; that is, certain

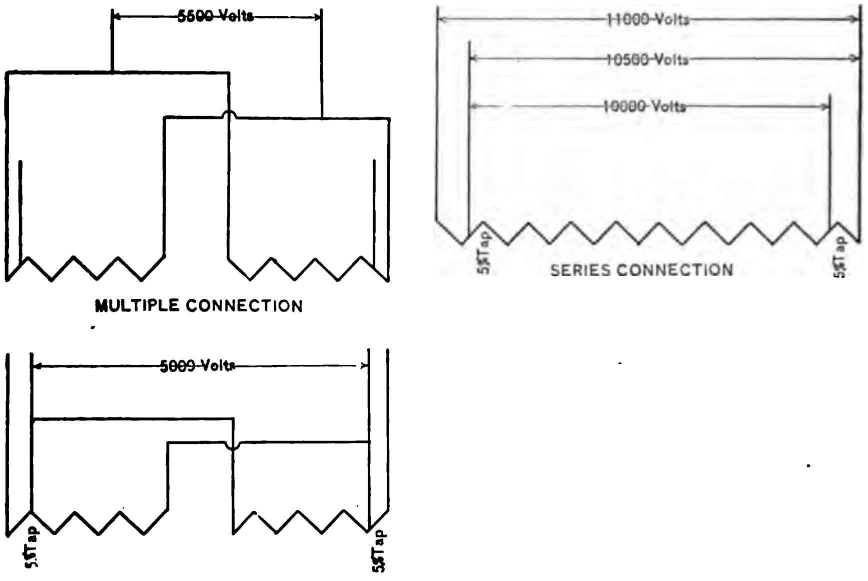


FIG. 2—HIGH-TENSION WINDING 5,000 AND 10,000-VOLT TRANSFORMER

nominal values were selected, and taps brought out for a suitable variation; for example, for a nominal voltage of 2,000, two taps are brought out so that the following voltages may be obtained: 2,200, 2,100, 2,000, 1,900. In many cases, however, low-tension windings must be arranged for series-multiple connection, so that two secondary voltages may be obtained;

for example, 200 and 400 volts. For this condition the same arrangement as was described for the high-tension is adopted; that is, a 10-per-cent tap is brought out from each half of the winding, as shown in Figure 2. For the 200-400 volt combination, the following values may be obtained: 200, 220, 400, 420, 440.

For rotary converters, the voltage required varies with the number of phases of the rotary and with the direct-current voltage that it supplies. With the transformers for this service, an alternating-current voltage is selected that will give the required direct-current voltage. This is considered the normal, and taps are brought out to give values approximately five per cent higher and five per cent and 10 per cent lower than normal. The following table shows the values adopted as standard for low-tension transformer voltages:

STANDARD LOW-TENSION TRANSFORMER VOLTAGES

Service	Normal Voltage	Other Voltages Obtainable		
General distribution........	6,000	5,700	6,300	6,600
" "	3,000	2,850	3,150	3,300
" "	2,000	.....	2,100	2,200
" "	1,000 and 2,000	1,100	2,100	2,200
Motors and Lights..........	200 " 400	220	420	440
" " "	100 " 200	110	210	220
Rotary Two-Phase				
500 Volts D. C.............	365	One higher and two lower values in steps of approximately five per cent.		
550 " "	400			
600 " "	435			
650 " "	470			
Rotary Three-Phase				
500 Volts D. C.............	315			
550 " "	345			
600 " "	375			
650 " "	410			

With large transformers, the volts per turn often reach a comparatively high value, and as taps can not be brought out at less than one-turn intervals, it is often impossible on low voltages to obtain steps of just the right percentage. In such cases the transformers are designed to give the correct normal voltage, and the taps are spaced to give values as near as possible to those desired.

It was stated that certain voltages had long been recognized as standard for small transformers used for supplying motors and lights. These voltages are nominally 1,000 and 2,000 on the high-tension side, and 50, 100, 200 and 400 on the low-tension side. There are, however, a large number of plants having transformers of special ratios, one of the most common being such as gives secondary voltages 10 per cent higher than the usual values. On many long feeders the drop is so great as to make it impossible to obtain full lamp voltage at the end of such feeders, and here it is also desirable to have some means of obtaining higher secondary voltages.

For such work, it has heretofore been necessary to purchase transformers specially wound for the voltages required, but the Westinghouse Company has recently adopted for its small transformers, known as Type N and Type O D, a method by which not only the standard but also special voltages may be obtained, thus greatly increasing the flexibility of the apparatus.

The high-tension winding of these transformers is wound in two parts, each for a nominal voltage of 1,000, thus giving 2,000 volts when the two parts are in series and 1,000 when in multiple. From each part a 10-per-cent tap is brought out, as shown in Figure 3.

With the two parts connected in parallel for 1,000 volts, the whole of the winding may be used, giving, say, a 10 to 1 ratio; or by connecting to the taps, a 9 to 1 ratio; the latter connection boosting the secondary voltage 10 per cent.

With the two parts in series, the whole winding may be used, giving, say, a 10 to 1 ratio; or by connecting to the taps five per cent or 10 per cent may be cut out, thus giving ratios of 9.5 and 9 to 1, respectively; the former connection boosting the secondary voltage five per cent and the latter 10 per cent.

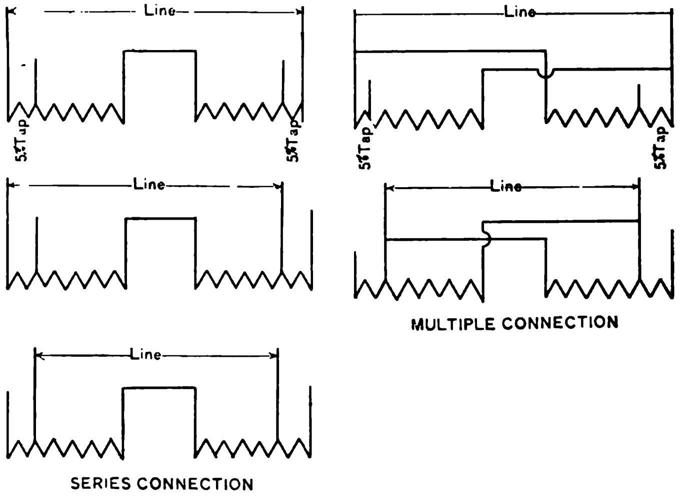


Fig. 3—Primary Winding of Type N. and O. D. Transformers

It is also of interest to note that these transformers are wound to give full output at three different secondary voltages: "Class 200" is arranged for 50, 100 and 200 volts, and "Class 400." for 100, 200 and 400 volts. These three secondary voltages, taken in connection with the taps on the primary, make an extremely flexible transformer, and one that will give satisfactory service over a wide range of operating conditions.

The following table shows the nominal voltage rating of these transformers; also the ratio for the different connections:

PRIMARY	SECONDARY			
	"Class 200"		"Class 400"	
Voltage	Voltage	Ratio	Voltage	Ratio
1,000	50–100–200	20, 10, 5 to 1	100–200–400	10, 5, 2.5 to 1
	55–110–220	18, 9, 4.5 to 1	110–220–440	9, 4.5, 2.25 to 1
2,000	50–100–200	40, 20, 10 to 1	100–200–400	20, 10, 5 to 1
	52.5–105–210	38, 19, 9.5 to 1	105–210–420	19, 9.5, 4.75 to 1
	55–110–220	36, 18, 9 to 1	110–220–440	18, 9, 4.5 to 1

The adoption of standard transformer voltages by one manufacturing company has been found thus far to give excellent results, and it is to be hoped that all the manufacturing companies may be able to unite upon certain standard values.

The use of standard transformer voltages means to the manufacturer a reduced number of specifications, drawings and patterns, fewer chances of error, and the possibility of manufacturing in large quantities; all of which tend toward a lower cost and quicker delivery. The use of standard-voltage transformers means that the user shares in the advantages gained by the manufacturer, and the possession of transformers that may be used interchangeably on different parts of his circuits is an advantage easily appreciated. It means to him the necessity of carrying in stock fewer spare parts and the possibility of obtaining such parts much more quickly than when special ones are required. It means the ability to shift apparatus from one part of his system to another, and, in general, a great increase in the flexibility of a vital part of his equipment.

DISCUSSION

THE PRESIDENT: Gentlemen, the paper is open for discussion.

MR. H. S. MOODY (Schenectady, N. Y.): Mr. Peck's paper deals with a subject that is extremely attractive to the transformer manufacturer. It is doubtful if many here appreciate the possibilities of improvement in this direction; for instance, the General Electric Company has in the past 10 years manufactured some 18,000 different transformers, which means five or six new designs per day. Is it strange, therefore, that any attempt to reduce the demand for new ratios should be welcomed?

The greatest obstacle to accomplishing any substantial results is the record that is behind us. Hundreds of plants—many of them extensive—are using transformers having ratios that should not be duplicated, but it can hardly be expected that they should be thrown away to accommodate the manufacturer. Frequently, consolidation of plants into large systems covering hundreds of square miles brings into one system transmissions using altogether different ratios, and new and undesirable ratios are needed to interconnect such systems. Again, all purchasers and consulting engineers do not as yet fully appreciate the advantages of standard ratios, which advantages they share almost equally with the manufacturers. Notwithstanding these discouraging aspects of the situation, there is much reason to expect improvement. New plants are constantly being started which are not tied to past practice, and the reconstruction of the older plants will gradually result in changes in the desired direction, provided the manufacturer constantly keeps before the purchaser the desirability of such changes. Perhaps one of the most useful agencies in bringing about the desired result will be the American Institute of Electrical Engineers. There is comparatively little to be gained by one manufacturer's adopting standards that differ from those used by all others, and there is little likelihood of different companies coming to an agreement as to desirable ratios by direct consultation. The Institute can well be used, however, as an unbiased medium for adjustment; the beginning already made is a hopeful indication.

I will call your attention to a few points to which Mr. Peck has not referred, or on which I think there will be some chance for difference of opinion. First, as to the range to be covered by standard taps in large units. Our experience shows that 10 per cent is usually sufficient; even this range means appreciably greater cost. With the 15 per cent suggested, five per cent being below and 10 per cent above normal, there must evidently be 10 per cent more turns and five per cent more cross section in the transformer winding than if there were no such adjustment. Desirable as it is to minimize designs, we must not lose sight of the fact that special windings can be furnished in transformers much more readily than in other apparatus and that the possible saving in the reduced number of designs is not great. Additional cost from adjustable ratios can easily counterbalance this saving. Our experience on the other hand is that five-per-cent steps are in most cases too rough an adjustment, but 10-per-cent range with two-and-a-half-per-cent steps has proved quite satisfactory, except where the ratio must be adjusted at different loads (as when supplying lighting rotaries), in which case much smaller steps and larger range are usually necessary.

Turning, now, to the smaller transformers for lighting, there seems to be less reason for adjustable ratios; such transformers, to give satisfactory regulation at the lamp, must be operated from centres of distribution with a negligible or equal drop between the centre and each transformer. It would appear that the feeder regulator, rather than the transformer, is the place to adjust for the variable drop in different feeders. The General Electric Company has for some time made a considerable portion of its smaller transformers with a 1 to 9 or a 1 to 18 ratio. This was not an attempt to allow for drop, but to give 110 volts or more for motors in plants having generators that would not admit of obtaining this voltage under full load. As 2200 to 2400-volt generators become more common, the 1 to 10 or 1 to 20 ratio will answer every purpose. I believe that a permanent adjustment of ratio by taps, except in the large units, operating on a line that always carries a considerable portion of its load, is to be avoided in that the adjustment can be right for only one condition of load and is, therefore, not a real remedy for variable drop. If such a tap is used to obtain a higher secondary voltage than normal, instead of to allow for drop, it is still objectionable, because when in use the core loss is approximately 20 per cent higher and copper loss 10 per cent less than that for which the transformer was designed. In these days, when so much effort is made to obtain a transformer of the highest possible "all-day" efficiency, it does not seem desirable to distort a good design so greatly as to increase the all-day losses 20 per cent.

Interchangeable voltages obtained by means of series multiple coupling of either primary or secondary sections are unquestionably desirable for the manufacturer and often for the purchaser as well. The extent to which it is best to carry such combinations only reaches its limit when the extra cost of so doing exceeds the saving following the reduction in the number of designs.

It is to be hoped that all purchasers and manufacturers of transformers will be in full sympathy with this attempt at standardization (already so well under way), and that in a few years we may see at least 80 per cent of all transformers purchased conforming to some generally acknowledged standard of capacity and voltage. The designing engineer can then devote most of his time to perfecting standards rather than hastily designing for special requirements.

THE PRESIDENT: We have heard from two manufacturers. We should like to hear from the central-station companies what they have to say about the standard ratio.

MR. P. D. WAGONER (Schenectady, N. Y.): I wish to emphasize the following facts in regard to the use of a transformer having both 18 to 1 and 20 to 1 ratio, the 18 to 1 ratio being obtained by taps in the primary. Such a transformer might be used for two purposes: First, to operate a complete 18 to 1 system, and second, to use the transformer connected for 18 to 1 ratio occasionally to compensate for line losses. Considering the first method of procedure, as the transformer would have approximately 18 to 20 per cent higher core loss than normal when connected for 18 to 1 ratio, it would be far more desirable to use a transformer designed for normal losses at this ratio. In regard to the second method of procedure, namely, the use of the 18 to 1 ratio to compensate for line loss, on careful consideration there are disadvantages in this method of procedure which do not appear at first sight. Large line losses, requiring the use of the 18 to 1 ratio, would occur during the period of the day when the system is running under approximately full-load conditions, which period would ordinarily be of three or four hours' duration. During this period, the voltage impressed on the primary would be below normal, and we could assume that it would be sufficiently below normal to give normal core losses and normal secondary voltage for the lamps. While the desired condition would be obtained for three or four hours of the day, during the remaining 20 to 21 hours practically normal voltage would be impressed on the transformer, and for this period the core loss would be 18 to 20 per cent above normal, and a secondary voltage considerably higher than normal would be obtained; therefore, any lamps that might be turned on during this long period would be subjected to abnormally high voltage.

All of the above remarks apply to the smaller sizes of transformers used for commercial lighting, and do not apply to transformers used for transmission purposes, rotaries, and so forth.

MR. C. C. GARTLAND (Sioux City, Ia.): It seems to me, upon the theory of the remarks of the gentleman who last spoke, that at the end of the line in taking advantage of the booster after the consumption of the line is lowered, the higher voltage would be a detriment to the line. It appears to be a question as to whether or not it would be practicable to adopt the tap. For instance, in taking care of line loss, take as an example a lead five miles long on which there are several large consumers and some smaller ones, and suppose some of the large consumers, near to centre of distribution, are in the habit of reducing their consumption of current early in the evening, while those in the suburbs use their lights considerably longer. Therefore, in tapping transformers, as the gentleman stated, we could take care of five-per-cent drop in secondary wires at a normal load; but when some of the heavy consumers near the central station turn off their lights, the consumers at the end of the line with lamps still in service will have extremely high voltage. Therefore, it seems to me that the loss in life of lamps and the unsatisfactory service would not be compensated for by the supposed benefit derived from a five to 10-per-cent tap from transformers. It is not customary nowadays for central stations to use much smaller than number six copper wire for carrying secondary current to buildings. It therefore develops, owing to the safety of wire of this size against sleet storms, etc., that there is very little loss to be taken care of in secondary wiring.

Mr. Wagoner: The submitting to abnormally high voltage of any incandescent lamps that might be turned on during the light-load period of the day would reduce the life of such lamps very materially.

Mr. Lieb: Mr. Wagoner's remarks and those of the gentleman who followed him have no reference to the desirability of having three, four, or more, taps on transformers that are used to step down to a secondary voltage for operating rotary converters. In such cases it is extremely desirable, where the high-tension feeders are of different lengths—as they must be to cover a large distributing territory—to have at least four or more such taps.

Mr. C. F. Hewitt (Elkhart, Ind.): I agree in a measure with Mr. Lieb's statement. We have found this second-tap feature useful in long lines feeding a combined motor and lighting load by assisting in keeping the voltage up at the extreme end, which is the point where motors are most frequently located; and it is also valuable in that it often eliminates the necessity for adding more copper to a line that is only moderately profitable, and to which it would not pay to add to the copper weight in an attempt to keep up a certain voltage at the end of such a line during the short lap of lighting and power loads. Here, the additional tap fits in conveniently; but I do not wish to be considered as recommending its use in connection with purely lighting work; I refer to its utility when embodied in the construction of transformers supplying current to motors only. When the motors are not in use, the voltage on the secondaries will of course be higher than at normal load, but not enough so to injure the transformer secondary windings.

Mr. W. G. Carlton (Chicago): The Chicago Edison Company has 9000-volt feeders, varying in length from one to five miles, and I do not see how we could operate without the different taps on the transformers so long as we operate on a common 'bus, as we do. In the air-cooled transformers we have had a little trouble, due probably to the method in which the taps were taken out, which makes an additional source of trouble; but there is little trouble of that kind. We lost two transformers, probably from that cause. We find it necessary to have these taps in order to get the regulation needed; otherwise it would be necessary for us to have excessive regulator capacity on the rotaries.

Mr. H. J. Gille (St. Paul, Minn.): I think the tap on the transformers for the distribution system is desirable, but I think it would also be desirable for the manufacturers to connect all transformers when they ship them. The taps are in such condition that they have to be tested out; they are not marked or tagged. It would be desirable to have the taps connected when the transformers are shipped.

Mr. H. C. Wirt (Schenectady, N. Y.): I think the question separates itself into a discussion regarding small and large transformers. I think the proposition to make transformers with interchangeable ratio of 20 to 1 and 18 to 1 for the convenience of manufacturers ought not to be considered favorably by central-station managers. What advantage is there to the central-station man using 18 to 1 ratio, in having a 20 to 1 transformer? The core loss will be increased when operating 18 to 1, and there will be a portion of the primary winding that is idle. This is making the convenience of the manufacturer of more importance than the economical operation of the transformer. It is much better to use a transformer having 18 to 1 ratio with the losses properly proportioned. There are two ways to make a transformer with interchangeable ratios. One is to bring a tap from the primary of the 20 to 1 transformer in order to get 18 to 1 ratio; the other plan is to have additional turns on the secondary, so that when operating 20 to 1 there will be idle turns on the secondary, and when operating 18 to 1 all the secondary windings will be in circuit. This plan will make the core loss the same under both conditions of operation and the copper loss would be changed only slightly. The disadvantages of this plan are the increased first cost and the idle secondary when operating 20 to 1. I think this question must be viewed from the standpoint of central-station managers, and not wholly from the manufacturer's standpoint.

Mr. J. S. Peck: It seems to be the consensus of opinion that the standardization of transformer ratios is a thing greatly to be desired; also, that for high-voltage transformers on long transmission lines it is desirable to have taps on the windings so that the secondary voltages can be adjusted. If it is true that for long-distance high-voltage transmission it is desirable to have means for adjusting the secondary voltages of the transformers, it seems to me also true that such means of adjustment is desirable for long-distance low-tension (1,000 and 2,000 volts) transmission.

Regarding the advantages of the double-ratio transformer—that is, one giving both 18 and 20 to 1 ratio—to central-station manager and manufacturer. It is to the advantage of the manufacturer to have a transformer giving both ratios, for, while the cost may be slightly increased, he is saved from carrying in stock two lines of transformers—one for each of the ratios. To the central-station manager there are several advantages in having a double-ratio transformer:

First—On long feeders he is able to compensate for the drop in these feeders.

Second—He is able to use lamps of special voltage, which is often found to be a decided advantage.

Third—In case transformer voltages are standardized, it seems possible that the 20 to 1 ratio may be adopted as a standard. This will leave the 18 to 1 as a special ratio, so that the man operating with the 18 to 1 ratio will require special transformers; and the delay incident to obtaining special apparatus is well known to the central-station man. If, however, double-ratio transformers are purchased, and it is finally decided to adopt the 20 to 1 ratio as a universal standard, the double-ratio transformer may at any time be changed from an 18 to a 20 to 1 ratio. The station will thus be on a standard basis so far as ratios are concerned. It is true that when full-line voltage is applied to less than the full primary winding a slightly greater iron loss is obtained, but the regulation and copper loss are improved, and in case of a low voltage due to feeder drop, the iron loss is not above normal.

The advantages of having a transformer wound for three secondary voltages—for example, 100, 200 and 400—are also of importance. Many electric companies have been formed by the consolidation of a number of smaller companies. These smaller companies have operated with secondary voltages varying from 50 to 100 volts, and it is of great advantage to have a transformer that may be used on any one of the three voltages by a simple change in secondary connections. We have found from a number of years' experience that some method of varying the voltage ratio of the transformer is of great utility, and cases are constantly arising where the increased flexibility of the variable-ratio transformer proved of great advantage.

Mr. Moody: I do not know that I have anything special to say in addition to what I have already said. It seems to me that the difference in "all-day" efficiency under such change of voltage as 10 per cent is sufficient to warrant using a transformer designed exactly for the conditions of operation. The use of the two ratios on a single feeder makes it impossible to maintain the right voltage at any one place under all conditions of load, and I believe there would be a temptation to the lineman—or whoever has charge of laying out such a distribution—to make connections to the tap rather than to add necessary copper to the feeder to keep the drop within an amount that is good practice.

With reference to the three secondary voltages, the additional cost of having two rather than three, is not great on a transformer of any considerable size, and it is really there that we find the use for the third ratio, because few small motors are wound for higher than 220 volts. On the small sizes, where the cost of the three voltages adds materially to the expense, there is little or no call for voltage higher than 220.

The President: I should have called on Mr. Peck to speak last, to close the discussion, and trust he will overlook my not having done so.

We will now take up a paper that is on the programme for to-morrow: "The Application of Four-Ampere Series Arc Lamps for City Lighting," by Mr. J. Henry Hallberg, of New York.

Mr. Hallberg read the following paper:

THE APPLICATION OF FOUR-AMPERE SERIES ALTERNATING INCLOSED-ARC LAMPS TO CITY LIGHTING

It is interesting to note that about twenty years ago, when the electric arc was first applied to street lighting, the open-arc lamps of high candle-power were used and were usually placed a considerable distance apart. These lamps operated at a high amperage (about ten amperes) with low arc voltage, producing a powerful, white, glaring light near the lamp, and as a general rule all street lamps were fitted with clear globes. This method of illumination impressed and satisfied the general public, who became accustomed to it, and thought the more glaring the light, the better the lamp and system. Such a system, however, though at that time a necessity, was not based on correct theories and principles. The main objections to this style of illumination are excessive shadows, unsteadiness of arc, and uneven distribution and poor diffusion of the light.

Later on, the "half-arc" (1200-cp) system was introduced to meet the demand for arc lamps from cities and towns that could not afford the "full-arc" (2000-cp) system, and from others that appreciated the importance of lamps of lower energy placed closer together. The introduction of this system was really a step in advance, although it was generally considered that a city or town that did not have a "full-arc" (2000-cp) street-lighting system, was not of much account. Some operators of street arc lamps realized the value of half-ground globes, and others went still further and placed "opal" globes on their lamps. Both ground and opal globes improved the diffusion and distribution of the light, but the general public would still, as a rule, object to anything but a clear globe.

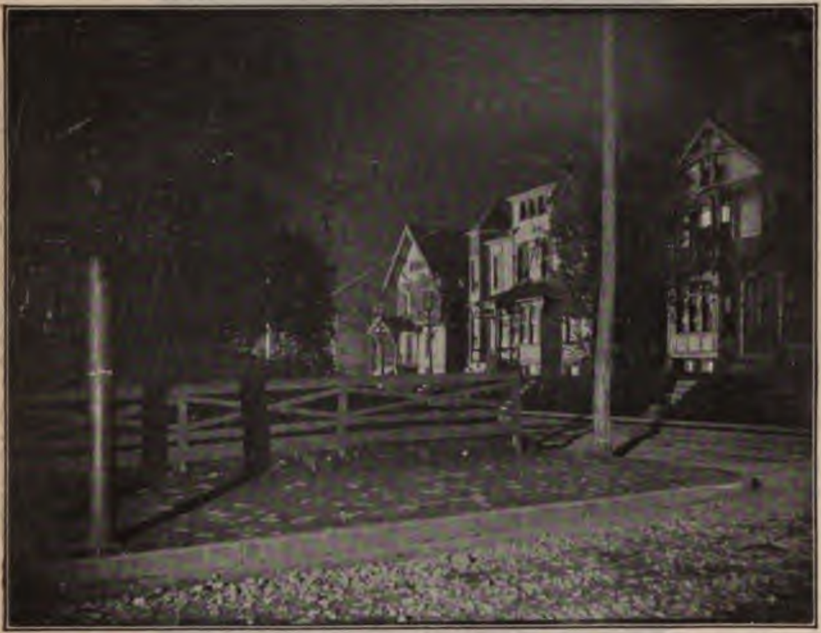


FIG. 1—NIGHT VIEW OF STREET IN CINCINNATI ILLUMINATED WITH FOUR-AMPERE SERIES ALTERNATING INCLOSED-ARC LAMPS, LOCATED ABOUT 350 FEET APART

Thus the street-lighting industry continued during the first 10 years of its existence, with 6.8-ampere (300 watts at the arc) and 9.6-ampere (450 watts at the arc) open-arc lamps connected in series and operated by special arc dynamos. The lamps were usually fitted with clear globes and were as a general rule hung at least 400 feet apart.

In 1893, the first demonstration of the successful application of low-energy arc lamps to city lighting materialized, when the New York Edison company equipped Fifth avenue (New York city) with six-ampere open-arc lamps operating two in series on about 118 volts direct-current.

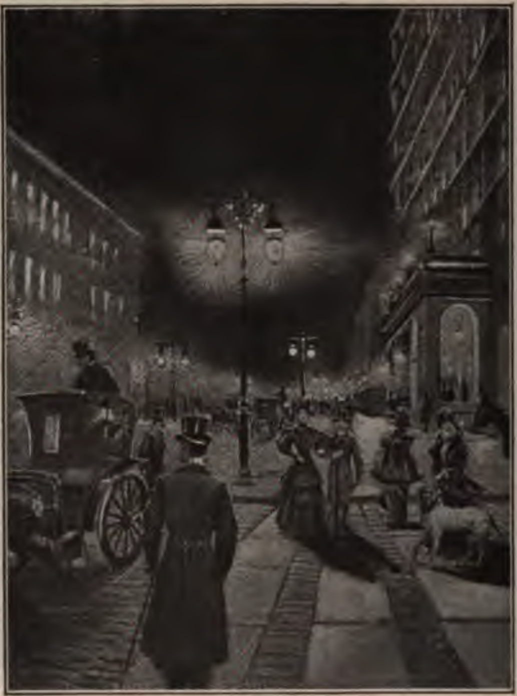


FIG. 2—NIGHT VIEW, LOW-ENERGY OPEN-ARC ILLUMINATION, FIFTH AVENUE, NEW YORK CITY, 1893

The lamps were equipped with "alabaster" globes and consumed about 270 watts each at the arc. Two lamps hung on each ornamental iron post, and there were two posts at each street intersection, placed on diagonally opposite corners, and between each cross-town street one post was located supporting two lamps. This method of street lighting proved successful beyond expectations, but it was, of course, expensive, on account of the large original investment, low efficiency, and cost of carbons and trimmings. The efficiency of the system, exclusive of generators and cables, did not exceed 76 per cent.

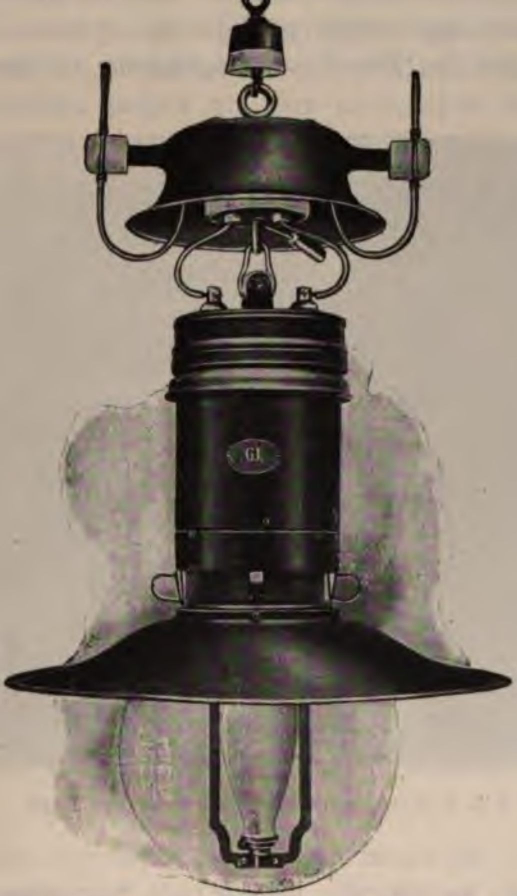


FIG. 3—CINCINNATI TYPE FOUR-AMPERE SERIES ALTERNATING ARC LAMP

In order to reduce the carbon and trimming expenses, three-ampere, 118-volt, multiple direct-current inclosed-arc lamps have now been installed on Fifth avenue, in place of the low-energy open-arc lamps. The efficiency of the present system, exclusive of generators and cables, does not exceed 70 per cent.

The commercial success of the already described and similar low-energy arc-lighting systems for city lighting, led the Board of Legislation of the city of Cincinnati to specify low-energy four-ampere alternating arc lamps for the lighting of the streets and alleys of the city of Cincinnati, and its suburbs and surrounding towns.

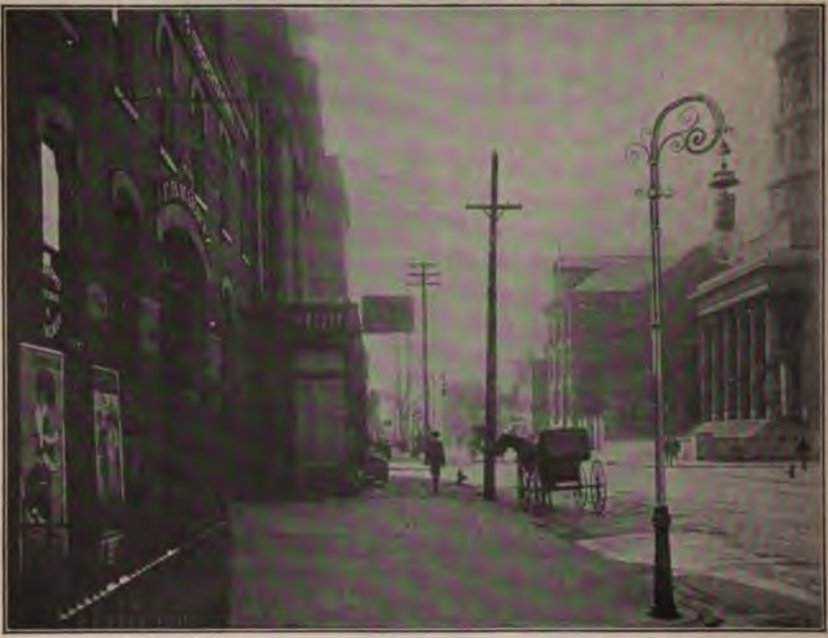


FIG. 4—CINCINNATI ARC-LAMP POST AND LAMP

The four-ampere series alternating inclosed-arc lamp, fitted with light alabaster inner and clear outer globes, with porcelain enamel metal reflectors and solid copper shells, was adopted and installed by the Cincinnati Gas and Electric Company.

In the "underground" or down-town district, the lamps are mounted on ornamental aluminum-painted all-iron posts. There are two posts at each street intersection, one each at diagonally opposite corners, and in addition thereto other lamps are so placed that at intermediate points no two consecutive lamps are farther than 133 feet apart. The lamps are placed on alternate sides of the street. On a few down-town streets the lamps are 300 feet apart.

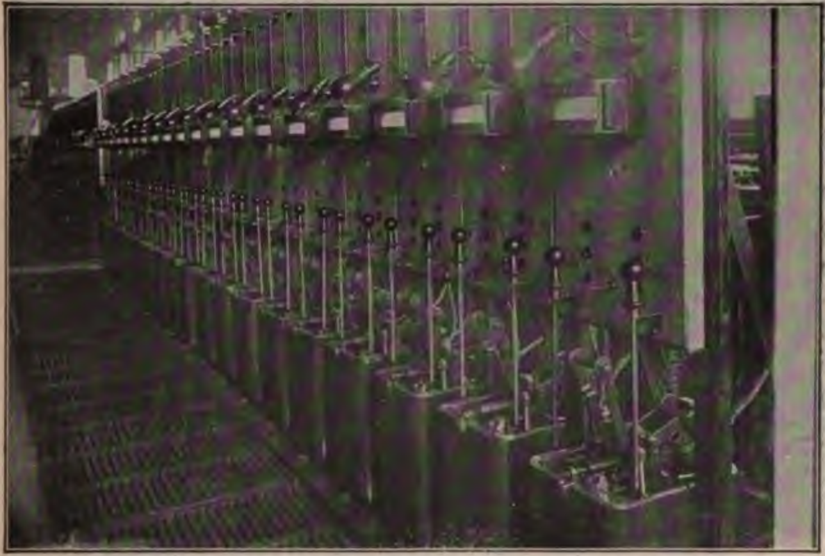


FIG. 5—CINCINNATI SWITCH PANELS IN PLUM STREET STATION FOR 2,100 ARC LAMPS

Each down-town circuit has a capacity of 60 lamps, and they are fed by underground lead-covered cables. There are about one thousand lamps operating on the underground system, which is controlled directly from the generating station. About one thousand one hundred additional lamps, operating on part overhead and part underground circuits, are also controlled from this station.

The "overhead" district, comprising equipment for 3,300 lamps, covers a large territory and is divided into three sections; each section is controlled from a substation, where the switching and regulating apparatus for about one thousand one hundred lamps is located. Each substation is supplied with current from the generating station through two three-phase cables; one cable carries the load and the other can be switched in case of a breakdown.

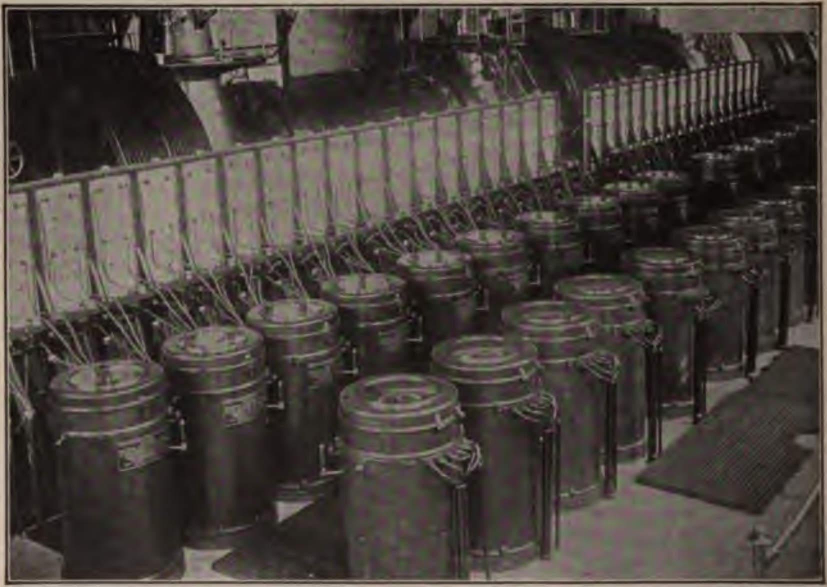


FIG. 6—AUTOMATIC CONSTANT-CURRENT TRANSFORMERS IN PLUM STREET STATION FOR 2,100 ARC LAMPS

The lamps in the overhead district are hung from 12 to 20 feet above the street, and are in no case more than 400 feet apart.

Ornamental metal brackets, mounted on painted wooden poles, support each lamp in the overhead district, and absolute cut-out hangers with special glass-insulating bells support each lamp.

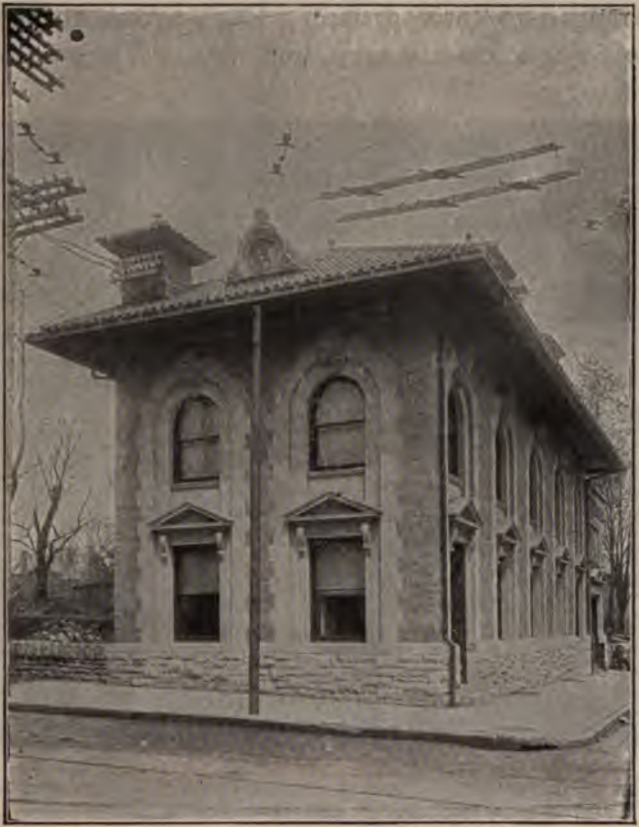


FIG. 7—WALNUT HILLS SUBSTATION FOR CITY ARC LIGHTING AT CINCINNATI

The larger part of this magnificent installation, comprising ninety automatic, constant-current, 60-light transformers, ninety combination static dischargers and lightning arresters, ninety 60-light switch panels and 4,500 series alternating-current copper-cased arc lamps, with absolute cut-out hangers, is now completed and the first circuits have been in operation about one year.

The entire arc-lighting system operates on a three-phase, 4500-volt, 60-cycle generator. Switching devices and automatic transformers in the generating station are arranged in three groups. Each group consists of twelve 60-light transformers, and any or all groups can

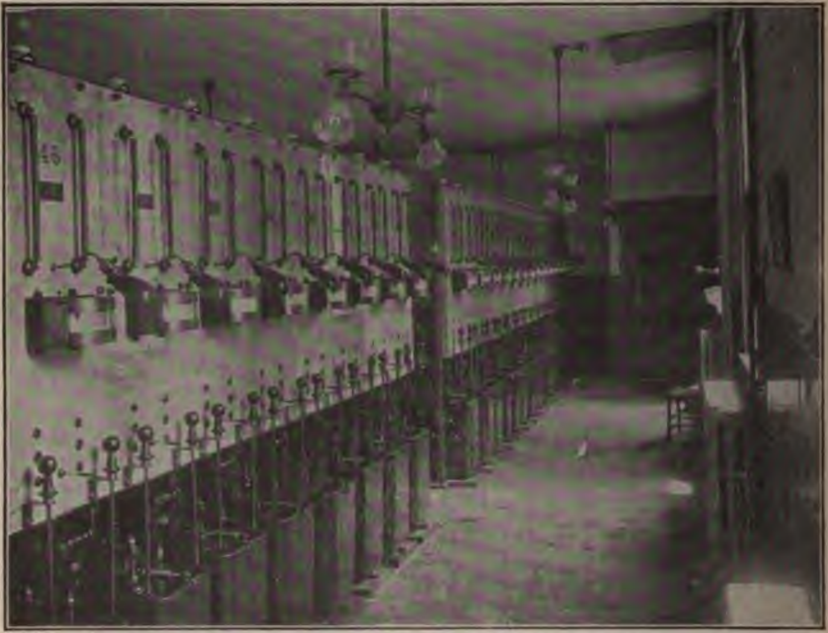


FIG. 8—SERIES ALTERNATING-CURRENT SWITCH PANELS IN WALNUT HILLS SUB-STATION FOR 1,100 ARC LAMPS

be switched on either of the three phases, which arrangement permits the proper balancing of the load on the three-phase system. The commercial efficiency of the system, exclusive of generator, lines and cables, is over 91 per cent. The initial power factor of the apparatus is between 70 and 75 per cent at all loads above quarter-load.

Due to the capacity of the lead-covered cables connected to the apparatus, the commercial power factor of the entire system is maintained from 10 to 15 per cent above the initial power factor of the apparatus, consequently the operating power factor of the installation is about 80 per cent. The current is maintained at exactly four amperes, and the lamps are adjusted for about 75 volts at the arc. Each lamp consumes 240 to 260 actual watts at the arc, and is equipped with half-inch carbons. Although this is a large diameter for the carbon for such a low-energy arc, the regulation of the lamp is perfect, and the light alabaster inner globe is well filled with a steady diffused light.

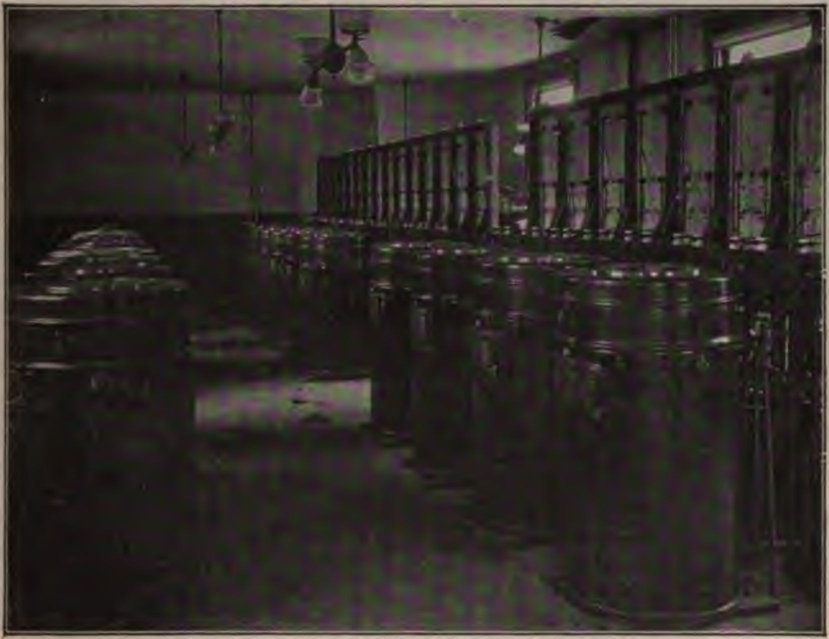


FIG. 9—AUTOMATIC CONSTANT-CURRENT TRANSFORMERS IN WALNUT HILLS SUB-STATION FOR 1,100 ARC LAMPS

The life of one .5" × 10" carbon is depended upon to be 115 hours.

The trimming of 4,500 lamps is taken care of by eight trimmers, who work on specially-constructed tower wagons.

The open-base inner globe is used, and all globes are cleaned at the substations, where the carbon stubs are also cut to proper length and fitted in an extra set of lower carbon holders for the next trim.

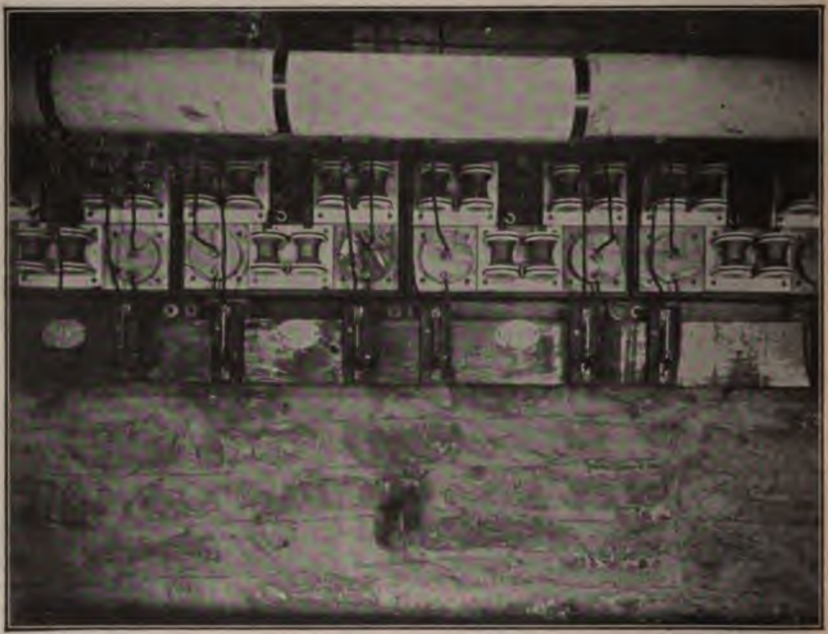


FIG. 10—LIGHTNING AND STATIC ARRESTERS FOR SERIES ALTERNATING ARC-LIGHT CIRCUITS

There are comparatively few people outside of those interested in street lighting who understand the value of low-energy series alternating-current arc lamps as applied to city lighting. Due to this fact, complaints may be expected from the public when a 9.6-ampere

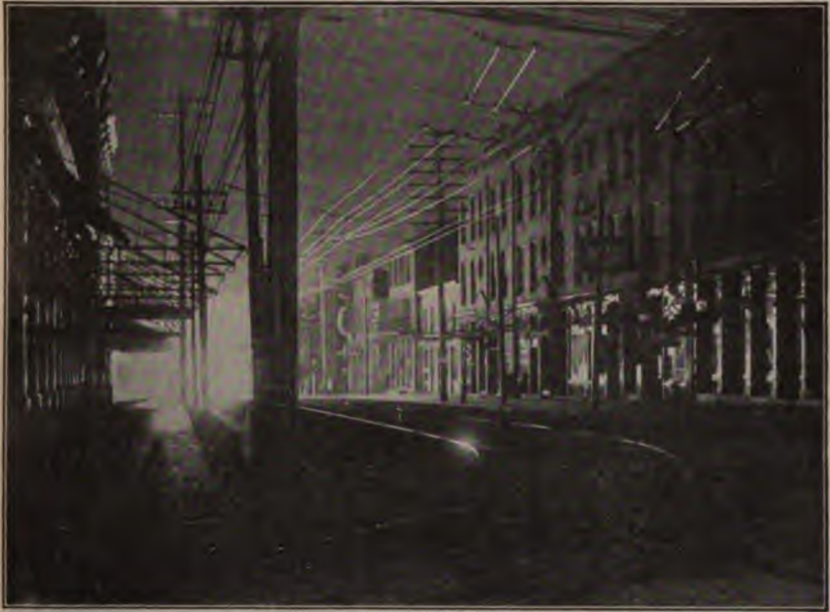


FIG. 11—NIGHT VIEW OF STREET IN CINCINNATI ILLUMINATED WITH FOUR-AMPERE SERIES ALTERNATING-CURRENT ARC LAMPS, LOCATED ABOUT 250 FEET APART

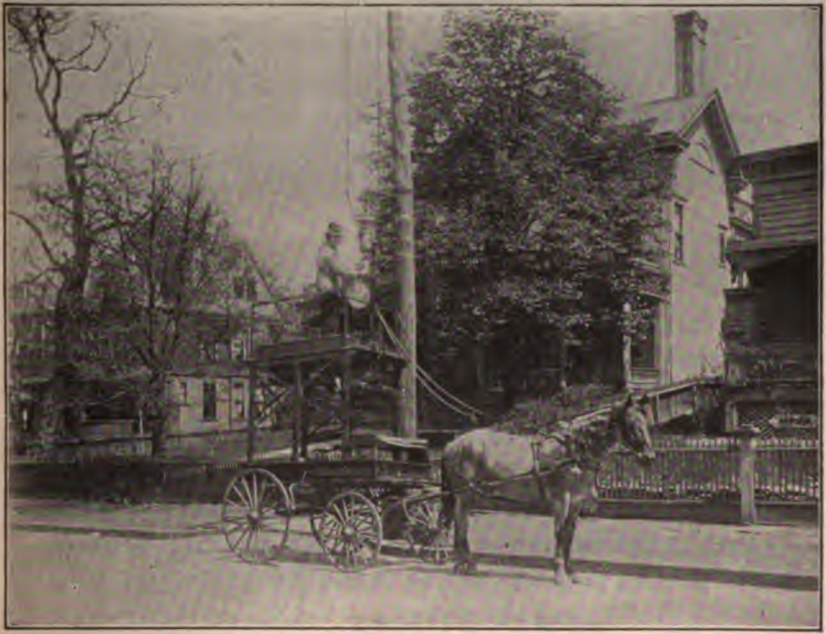


FIG. 12—TRIMMING FOUR-AMPERE SERIES ALTERNATING STREET ARC LAMPS AT CINCINNATI

open arc is replaced with two low-energy series alternating lamps. It is, however, an interesting fact that when a change of this kind is made and established, the public soon realizes the advantage of a steady, shadowless, well-distributed and diffused light, and would not willingly go back to the old method of illumination.

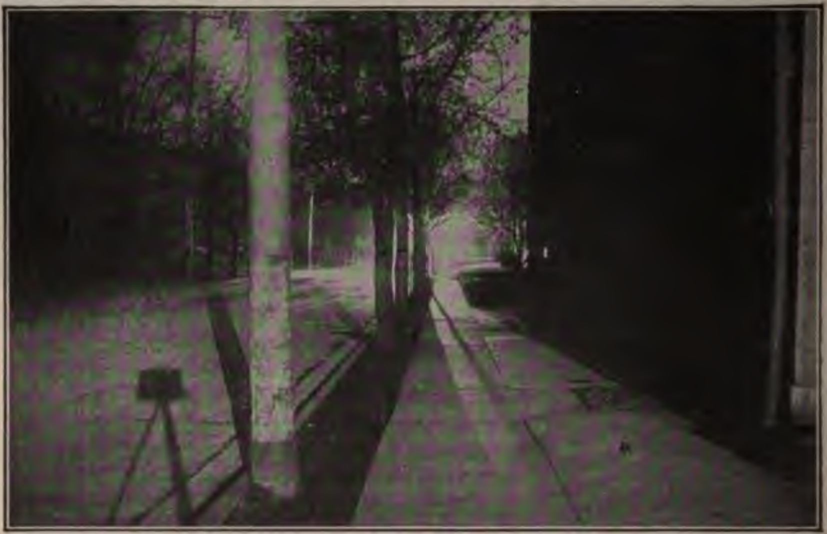


FIG. 13—NIGHT VIEW OF STREET IN CINCINNATI ILLUMINATED WITH FOUR-AMPERE SERIES ALTERNATING-CURRENT ARC LAMPS, LOCATED ABOUT 400 FEET APART

The writer's experience at Cincinnati during the past year has established the following facts:

First—The open-base inner globe is safer and more economical than the closed-base globe.

Second—The large metal reflector is not necessary on four-ampere series alternating-current lamps hung only 12 or 15 feet above the street, but a small enamel reflector immediately above the arc is beneficial.

Third—The initial or natural power factor of a four-ampere series alternating-current system should not be depended upon to be greater than 75 per cent, varying between 70 and 75 per cent.

Fourth—The 75-per-cent power factor applies to ordinary overhead circuits. When the current is supplied underground in lead-covered cables, the capacity of such cables introduces leading currents, hence the operating power factor of the underground circuits at Cincinnati is maintained above 90 per cent.

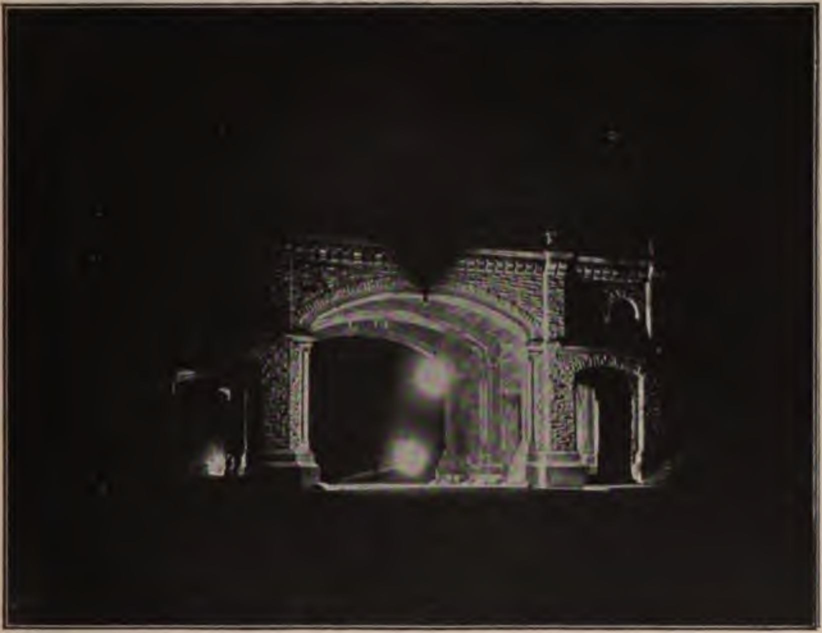


FIG. 14—NIGHT VIEW OF ENTRANCE TO EDEN PARK AT CINCINNATI, ILLUMINATED WITH FOUR-AMPERE SERIES ALTERNATING INCLOSED-ARC LAMPS

Fifth—The efficiency can be maintained above 91 per cent and the regulation still be perfect.

Sixth—Four amperes is the lowest practical limit at which successful alternating-current arc lighting can be practiced.

Seventh—Half-inch diameter carbon is the most practical size to use in a four-ampere alternating-current lamp.

Eighth—Notwithstanding the large size of the carbon (considering the low-energy arc), the regulation of the system is perfect, and there are no objectionable shadows from the carbons.

Ninth—It requires only eight trimmers to take care of 4,500 lamps.

Tenth—The outages or lamps requiring starting in the underground district are less than one-fourth of one per cent, and in the overhead district the outages average three-fourths of one per cent.

The practical and commercial success of the application of the four-ampere series alternating inclosed-arc lamp to city lighting, as applied to the largest arc-lighting installation in the world, has herewith been called to the attention of this association, and the writer hopes that this paper and the illustrations will throw further light on one of the most important questions of the day.

NOTE—The cuts of the Cincinnati installation for this paper were made from the original photographs, which had not been retouched or altered in any way. The exposure for the night views varied between 30 and 45 minutes.

DISCUSSION

THE PRESIDENT: I will call on Mr. Ryan to say something on this subject.

MR. W. D'A. RYAN (Lynn, Mass.): There is very little that I care to say with regard to the use of small-current lamps as compared with high-current lamps for street illumination. The four-ampere arc has certain advantages in distribution over the six-ampere arc; that is to say, the distribution obtained by having a large number of small units for a given expenditure of energy per mile overcompensates for the higher individual efficiency of the small number of large units for the same expenditure of energy, and for this reason there is a considerable theoretical gain in effective illumination on the streets by the use of small units; particularly for suburban service, where building reflection does not enter largely into consideration. I use the term "theoretical gain," because in many instances it would not be practical to place lamps at distances that would give the highest street-illuminating efficiency, owing to the distance between cross streets, wishes of the community, and other local conditions.

Mr. Hallberg states that he is using half-inch carbons. In my opinion better results would be obtained by using three-eighths-inch carbons to cut down the wandering of the arc. With half-inch carbons and a small current, the lighting when the arc is on the side of the carbon is practically three times as strong as it is on the opposite side, and the light on the weak side is considerably out of balance to violet. The use of a small carbon with small current overcomes these difficulties to a considerable extent.

MR. BERTRAND: I would ask Mr. Hallberg how the outages are figured.

MR. HALLBERG: Due to the fact that all series alternating-arc lamps in the city of Cincinnati are equipped with absolute cut-out hangers, and to the method of trimming from tower wagons, the Cincinnati Gas and Electric Company is able, if necessary, either to start or exchange any lamp on the system which has been reported out by the police, inside of two hours after such lamp has been reported to the company's inspectors. The outages referred to on page 236 include all lamps that refuse to start up when the current is switched on the circuit. The inspectors carry a few extra lamps, carbons and inner globes in their tower wagons, so that they are prepared when they arrive at the troubled lamp to exchange the lamp if it has been injured, or to re-carbon the lamp if the carbons are prematurely consumed—which might happen if the inner globe were broken or an excessive amount of air admitted in any other way. When the lamps were first installed a number of outages were reported that upon examination were found to be due to the fact that the carbons were not properly clamped in their holders. Under this condition the lamp would not open the cut-out, as the resistance of the carbon circuit was greatly increased and the greater part of the current passed over the cut-out and through the series starting resistance instead of passing through the carbon circuit and then through the series magnet coils. Since the trimmers have become more expert, trouble calls of this kind have been practically eliminated.

MR. BERTRAND: My point is this: Is the outage figured as the sum of the lamps burned multiplied by the number of hours they should have burned?

MR. HALLBERG: The outages are reckoned on the number of lamps installed. For example, if 10 lamps out of 1,000 are reported out, the outages equal one per cent. There are at present about 4,500 lamps in operation in Cincinnati, and the trouble calls from this number of lamps fluctuate between 20 and 40 lamps per night.

MR. BERTRAND: What is the relative illumination from a four-ampere and a 6.6-ampere lamp?

MR. HALLBERG: That is a difficult question to answer, but I venture to say that for the same amount of energy expended in a mile of street the four-ampere illumination will probably be more uniform and agreeable to the eye, as the number of light units will be materially increased and therefore the distribution and diffusion of the light should be better.

The additional increase in the original investment for the four-ampere lamp, due to the increased number of lamps, fixtures, regulating devices, etc., should of course be taken into consideration when a comparison of the high and low-energy distribution is to be considered. The four-ampere distribution will of course show less advantage over the 6 6-ampere distribution than it will if compared with the 7.5-ampere system. However, opinions differ so widely on this subject that local conditions should always be considered, and the sentiment of the public should have some weight on this question.

MR. WIRT: I have given considerable thought to the question of low-current series lamps, and it seems to me that the paper just read does not show that a four-ampere system is preferable to one having higher current. When the standard currents were adopted the field was open to any manufacturer to adopt the proper current, and after considerable thought the 6.6-ampere series alternating system was chosen, as having about as low a current as was suitable for street lighting. It was thought that there was a demand for a lamp having a higher current, and the 7.5-ampere lamp was therefore standardized. When you have a four-ampere system it means less than four amperes passing through the arc, owing to the current absorbed in the shunt coils. I should like to know approximately what current through the arc is used in Cincinnati. In our consideration of the subject we have planned that if we standardize so low a current as four-ampere circuit we should adopt 4.4 amperes in the main circuit, so as to give us four amperes in the arc itself. I should like to know if the four-ampere system was selected for Cincinnati on account of the economy, or if the system was specified by the City Fathers. It seems to me that if the revenue per kilowatt output from the station would be the same, it would be less expensive to operate a 6.6-ampere system as compared with a four-ampere, on account of the first system having a less number of lamps to be taken care of. It is a fine question of economy. If we use a small light unit and a larger number of lamps, the cost of maintenance is increased, and the cost of wiring or the number of circuits is an important item. Let us say that 60 lamps in one circuit should be the limit, on account of the voltage, which would be approximately 5,000 volts. For the same kilowatt capacity the smaller light unit would require a larger number of circuits. One objection to the inclosed-arc system is that the number of volts per lamp, which is 75, is considerably higher than the number of volts per lamp used in the open-arc system, which is 45, and with the inclosed-arc system the street wiring has to be nearly duplicated; then, with the four-ampere lamp you require still an additional number of circuits for the same kilowatt output from the station. I do not see, therefore, where the economy comes in in using the four-ampere lamp instead of the 6.6-ampere.

MR. ARTHUR WILLIAMS: I would ask Mr. Hallberg, if I may, what the city pays for these lamps, and how he figures the difference in efficiency between the low-tension Edison system —which he gives as between 70 and 75 per cent—and his system at 91 per cent. I should also like to ask if the amperage is correctly stated, that is, whether it is approximately or exactly four amperes; because I have understood that the system at Cincinnati at four amperes has not been an entire success. There has been some difficulty, I believe, in getting satisfactory results from four-ampere alternating-current arc lamps. On page 234 appears the statement that "the open-base inner globe is safer." Will Mr. Hallberg kindly define the word "safer"?

Mr. Lieb: There is a statement made on page 226 regarding the efficiency of the lamps on Fifth avenue. The city arc lamps on Fifth avenue are fed from the low-tension mains supplying the incandescent light customers, and it seems to me that a bare statement as to the efficiency of the system does not tell the whole story; and while, in a condensed paper of this kind, Mr. Hallberg may not have intended to enter into the whole question, yet a bald statement like this should have been qualified. I think that if Mr. Hallberg were to investigate the other conditions of the problem, he would find that, while it may be true that the bare arc efficiency of the system might be 70 per cent in one case and 90 in the other, if all the elements of cost entering into the supply of current are taken into account, the relative commercial efficiencies may be reversed. I simply call attention to the fact that the mere statement of arc efficiency does not tell the whole story, and it should be qualified by a statement as to the other elements entering into the cost of the lighting.

Mr. Hallberg: In reply to Mr. Lieb's question referring to the efficiency of the present Fifth avenue system, which I stated to be 70 per cent, as compared with the efficiency of the present Cincinnati system, which is 91 per cent, I beg to state that in both cases the efficiencies given include only the lamps and necessary regulating devices. In the Fifth avenue case the system comprises a large direct-current source of supply, with arc lamps operating in multiple over a low-tension Edison three-wire system of distribution. The Cincinnati plant comprises one or more large alternators, which supply current to automatic constant-current transformers, and from them the current is carried through No. 6 B. & S. wire to the arc-light circuits, each one of which has a capacity of 60 lamps.

Mr. Lieb also referred to the maintenance of cables, etc., which should be taken into consideration when the efficiency of the plant is to be considered. This point is well taken and should of course have due consideration; but you will note that my paper is not intended to bring out the relative merits of high-tension alternating and low-tension direct-current systems of distribution, but is strictly confined to the merits of the four-ampere series alternating street-lighting system.

I am informed that the alternating-current generating apparatus and general system of distribution at Cincinnati are giving excellent results, and that the expense of maintenance is well within limits. The arc-light circuits at Cincinnati operate at a pressure between 4,000 and 5,500 volts, depending on the number of lamps connected in the circuit. The current is supplied in the underground district through rubber-insulated and lead-covered cables, and in the overhead district all line wires are of the ordinary No. 6 B. & S. gauge, triple-insulated, weather-proof style. There have been no electrical breakdowns in the underground district of the Cincinnati installation, although this part of the installation supplies over 1,000 lamps and has been in operation about one year.

It is of the greatest importance that all lamps on a high-tension series alternating system be thoroughly insulated from the ground, and, furthermore, static arresters with comparatively small gaps should be properly connected to each circuit, for the purpose of discharging any extra currents (of high potential) that may be generated in the system owing to the capacity of cables and line wires.

The immediate success of the large arc-lighting installation in Cincinnati is undoubtedly due to the complete equipment of this plant, and the extra good workmanship in the installation of the system. Thus far, there has been no appreciable depreciation of any of the apparatus or cables at Cincinnati, and the service is more reliable than it used to be with the high-tension 10-ampere Brush arc machines and open-arc lamps.

MR. WILLIAMS: I have a further question: Wherein lies the justification for complicating and duplicating a distributing system in such a city as Cincinnati, where the three-wire direct-current distributing system is already in existence? How can that duplication be technically or commercially justified?

MR. HALLBERG: I do not know whether or not I have answered all of Mr. Williams' questions, but I think that most of them are in line with those brought up by Mr. Lieb.

MR. WILLIAMS: The cost of electric lighting was the first one.

MR. HALLBERG: The city of Cincinnati pays to the Cincinnati Gas and Electric Company $72 per year for each four-ampere lamp connected to the overhead system.

MR. WILLIAMS: On page 234 the word "safer" is used; safer from what?

MR. HALLBERG: Referring to the paragraph on page 234 where I state that the "open-base inner globe is safer and more economical than the closed-base globe," I would say that inclosed-arc lamps were originally equipped with the open-base inner globe, and this style of globe proved to be entirely satisfactory and successful. Later on, however, some manufacturers applied the closed-base inner globe to the inclosed-arc lamps with more or less success. When the closed-base trim and inner globe is applied to an arc lamp, it is necessary to provide means for holding the lower carbon inside of the globe. The usual method is to provide a metal arm which runs down from the base of the lamp to the bottom end of the lower carbon where a suitable lower-carbon holder is provided. It is necessary that the inner globe, in an inclosed-arc lamp, should be as small as possible, in order to prolong the life of the carbons. On this account it necessarily follows that the metal arm inside of the globe must run close to the arc and carbons. On low-tension arc lamps the closed-base trim and inner globe with the metal arm near the arc can be used without any danger of the arc jumping from the upper carbon to the metal frame that supports the lower carbon. On high-tension lamps, or lamps drawing extra long arcs, there is a liability of the arc jumping from the upper carbon to the metal frame inside of the globe; and when the arc has once been established between these two points, it is only a matter of time until the lower frame, inner globe and trim are ruined, which not only puts the lamp out, but also involves considerable expense for repairs. The arc is most liable to jump to the lower frame when the lamp is trimmed with new carbons of the cored type—which are necessary with alternating lamps—as the arc is then subject to flaming and is always close to the metal frame. There are other causes for the flaming of the arc, such as high-feeding voltage of series lamps—which may be due to improper adjustment of the lamp mechanism—chipped or broken inner globes, and imperfect carbons. The various troubles above referred to have been experienced by many operators and manufacturers of inclosed-arc lamps during the past few years, and constant changes of design in the trimming devices for closed-base inner globes have not yet entirely eliminated troubles due to this form of trim. Many lamps in operation with closed-base trimming devices are giving considerable trouble, and some people are willing to put up with and pay for the repairs due to such trouble; but the Cincinnati Gas and Electric Company decided, after careful consideration of both the open and inclosed-base trim and inner globe, to adopt the open-base style, and the above facts were their principal reasons for coming to this decision.

There is another feature that should be considered, and that is that the breakage in handling will be greater with the closed-base inner globe. Extensive tests have proven that the breakage due to the heating of the arc is not greater with the open base, and the cost for renewals for the closed-base inner globes is approximately 25 per cent above the same cost for the open-base style. The closed-base inner globe has a much larger top surface than the open-base type, therefore the top edge is more liable to chip and crack; and a chipped or cracked inner globe should never be used on an inclosed-arc lamp. The very fact that it has taken the most prominent arc-lamp manufacturers more than two years to decide whether or not they should adopt the closed-base inner globe for any style of lamp, on account of the troubles above referred to, should be sufficient evidence that it is not quite as good as the open-base type, and it has not been tried so thoroughly and satisfactorily. I believe the above answers Mr. Williams' questions.

MR. BEAN: Are the four-ampere arc lamps at Cincinnati hung at 12 and 15 feet so hung that they cast a shadow?

Mr. HALLBERG: The Cincinnati four-ampere lamps are practically free from shadows, even though they are equipped with half-inch carbons, which is a comparatively large size of carbon for such a small amount of current at the arc.

Referring to Mr. Ryan's statement that three-eighths-inch carbons in the lamps would materially improve the illumination, I would say that, in a general way, I agree with him when clear inner globes are used, but with alabaster inner globes the diffusive power of the globes is sufficiently great to counteract any displacement of the arc.

MR. BEAN: How many feet high are the arc lamps in the city?

MR. HALLBERG: In the downtown district the lamps hang approximately 12 feet above the curb, and in the overhead district the lamps are hung between 12 and 20 feet above the street, depending on the nature of illumination required; that is, where the foliage of the trees is low the lamps are hung low, and where the streets are practically free from trees the lamps are hung higher.

MR. BEAN: Are there any shadows?

Mr. Hallberg: No, there are practically no shadows, as the alabaster inner globes diffuse the light perfectly. There can be no comparison between the open and inclosed arc in this respect, as the light from the inclosed arc is absolutely steady and well diffused. The lamps are hung, on an average, 250 feet apart.

Mr. Bean: I saw an installation of the Manhattan lamps on 40-foot poles; it is a succession of lights and shadows. And that is called a 6.6-ampere lamp, as I understand it, and something like 75 or 80 volts. Shadows were quite perceptible and the lamps did not give a smooth light. I am familiar with the streets of Cincinnati, and was anxious to know if there were any shadows cast by these lamps. I would also ask Mr. Hallberg if he figured the cost of distributing light in Cincinnati with 4,500 four-ampere lamps. The question of cost arises, as to whether you would get better results with such lamps and get rid of shadows.

Mr. Hallberg: When 7.5-ampere or high-energy arc lamps are to be installed it is necessary, in order to obtain proper distribution of the light, that the lamps should hang at least 25 feet above the street; and even at that height the 7.5-ampere arc is objectionable to the eye and the shadows are sharp and enlarged to a considerable extent. On account of the high suspension necessary for the 7.5-ampere lamps, a considerable amount of light is sacrificed and the general illumination is not uniform, in this respect approaching the open-arc lamp, as already referred to in my paper. The four-ampere series alternating inclosed-arc lamp, when properly installed, furnishes a uniform and steady street illumination of high commercial efficiency. The ideal illumination, in my opinion, is of such a nature that it does not disturb the optic nerve, and it softens the definition between lights and shadows as much as possible. The four-ampere alternating-current arc lamp will practically meet these conditions.

The President: We have another paper, not exactly on this subject, but kindred to it. It is entitled "Notes on the Inclosed Electric Arc." The paper is written by Professor Elihu Thomson. He was kind enough to promise me that he would be present at this convention, but, as you learned this morning from the letter he sent, owing to his mother's illness he was unable to be here. His paper was scheduled for to-morrow, but as this seems an appropriate time to consider it I will ask Mr. Ryan to read the paper.

Mr. Ryan read Professor Thomson's paper, as follows:

NOTES ON THE INCLOSED ELECTRIC ARC

The inclosed-carbon arc, in its behavior and effects, presents such points of difference from the arc burned in free air that a presentation of a few notes or explanations of these differences between them, together with considerations bearing in particular on the inclosed arc and its working, may be useful.

In the, open arc, the fairly rapid combustion of the carbons by the oxygen of the air adds itself to the effect of the arc proper; namely, the hot-vapor stream indicating the passage of the current. The result is that the carbons burn with tapered ends; the positive with direct current generally acquiring a well-defined crater, the size or area of which (under equal conditions) depends on the current strength. In the case of alternating currents, a less perfectly defined crater forms on the ends of both carbons.

In the inclosed arc we have the combustion reduced to a minimum, with the result of causing the ends of the carbons to remain nearly square or very blunt, with the added necessity for the production of a longer arc and the use of a higher impressed voltage. These facts are well known; about 65 to 70 volts being found to be the minimum potential difference that can be used, while with the open arc it is normally from 40 to 50. Any attempt to shorten the arc and thereby reduce the voltage, results, with a well-inclosed arc, in solid carbon deposits on the negative carbon, which may accumulate to such an amount as to shunt the arc as a solid conductor. The effect is much the same with open-air arcs, which when unduly shortened produce similar mushroom graphitic carbon deposits on the negative. In the open-air arc, however, these deposits are undercut by the combustion of the point of the negative on which they rest, and as a consequence they drop out from time to time, thus relieving the situation. This does not occur with the inclosed arc, and the conditions remain indefinitely. In the inclosed arc the deposits, once begun, accentuate themselves by still further shortening the arc, and, owing to the paucity of oxygen, can not be burned away so as to drop freely out from between the carbons as in the case of the open arc.

On account of the square ends of the carbons in the inclosed arc, it would be disadvantageous to shorten the arc, even if the solid carbon deposits did not form. Such shortening would obstruct the free radiation of light from the hot ends of the carbon, more particularly from the crater surfaces, which gradually shift their position or travel about the flat end of the carbon. Too close approximation of the carbon ends would also greatly accentuate the inequalities in the emission of light, which, as the arc moves from side to side, are sufficiently noticeable. The valuable commercial result attained by the inclosure of the arc is, of course, the saving of the cost of frequent trimming and carbon renewals. Another result is that single lamps, taking a large percentage of the voltage across the ordinary low-voltage mains, can be employed in parallel with incandescent lamps, a choking resistance being incorporated in series with the arc to take up the excess voltage and also to steady the current, which would otherwise be unstable. With the alternating current the waste in the choking resistance is obviated in large measure by employing, instead, inductance coils in series with the arc. The saving thus effected makes up for the comparatively lower efficiency of the alternating-current arc.

It may be asked here whether more complete inclosure of carbons or more perfect exclusion of air would not give still greater life to a single pair of carbons. Experience has, however, shown that it is easy to go too far in checking combustion, and that the ideal condition is one in which the carbons undergo a slow actual combustion in an atmosphere that contains at any time only a small amount of oxygen available for union with the hot carbon. This atmosphere is composed chiefly of nitrogen, carbonic oxide, carbon dioxide, and what little free oxygen passes in with the leakage air, entering mostly around the upper carbon through the opening in the metal cap resting on the surrounding small glass inner globe, so-called. It is even possible that what oxygen enters the inclosure is combined at once with carbonic oxide to form carbon dioxide and that the real waste of the carbon takes place from the latter gas dividing its oxygen with the carbon and again forming carbonic oxide in the globe. This is an action that, in fact, occurs in every anthracite coal fire.

When, however, the supply of oxygen to an inclosed arc is so completely cut off as almost to check oxidation of carbon, it is then found that in spite of the elongation of the arc, and consequent high voltage as compared with the open arc, the carbon mushroom deposits again form, and, what is also very objectionable, the upper part of the globe becomes coated with soot or unconsumed carbon, volatilized in the arc and condensed without combustion. This deposit actually tends to shut off the entering air, and in any case so exhausts the entering air of its oxygen as to prevent any from reaching the arc. With inclosed arcs, burning upon constant-potential direct-current circuits, in branches from those circuits, there is always such a variation of current that a continual slight pumping action of the upper carbon takes place, the effect of which is to cause the entrance of air to the globe. When the carbon descends, a little hot gas is expelled, and when it rises again, cool air (with oxygen) is drawn in. So great can this automatic ventilation of the inner globe become that, in spite of the careful fitting of the upper carbon to the opening in the metal cap, the complete closure of the cap with the upper edge of the globe ground flat, and the packing of the joint at the base of the globe, too much air can enter and shorten the carbon life unduly. Should the pumping action become excessive, as when there is too little steadying resistance in series with the arc, much of the advantage of inclosing the arc is neutralized. Unsteadiness, then, due to instability of current, is not alone detrimental to the character of the light, but may tend to rapid oxidation and consumption of the carbon.

In order to lessen the exchange of air for gases by this pumping action, the cap on the globe was modified. Instead of allowing the upper carbon to pass through a simple opening in the gas cap, the cap was thickened and an open space or chamber provided around the carbon within the body of the cap. The effect of this was to provide a sort of gas check, which lessened the rate at which the interchange of outside air and gas took place. It was as if the cap had been made in two parts, an upper and an under floor, each with a fairly closely fitted opening through which the carbon passed, and between them an intermediate space having within neither air nor gas alone, but a mixture of both. It is easily seen that by this arrangement the effect of the pumping section and the leakage were greatly diminished, though not entirely checked. The next move was even more radical. This was the providing of an open but lengthened passage between the outer air and the interior of the globe, independent of the fit of the upper carbon in the central opening of the cap. In this case the pumping action simply moved a column of air back and forth within the lengthened passage, and the diffusion of air into gas, or the reverse, only took place at a very slow rate. The lengthened passage was naturally made in the gas cap itself. The result has been a considerable gain in the life of the carbons. It has even been found that with this provision to check leakage the check was, in some cases, too complete. For example, on constant-current circuits regulated closely to a definite value of current, there is, of course, no such pumping or oscillation of the upper carbon as occurs with constant-potential circuits feeding the arc lamps, and therefore no supply of oxygen for the combustion of the carbon reaches the inner globe as a result of movement of the carbon. With the alternating current, however, the very intermittence of the arc flame tends to the introduction of air or oxygen.

In some cases of constant direct current it has been found that the exclusion of air might be so perfect as to give rise to carbon deposits on the negative, soot deposits on the upper part of the interior of the inner globe, soot deposits on the cap, and soot packing in the slight crevice around the upper carbon where it passed through the cap. The consequence is complete failure of the lamp as a source of light. The very beginning of deposition of soot completes the exclusion of air by its packing into the leakage spaces. The remedy in such case is to provide for a sufficient leakage, which will allow the proper combustion of the carbon. This can always be accomplished by giving a greater play of the upper carbon in the opening through the cap; that is, by widening this opening, or by a special small opening or leak. When the amount of oxygen of the air that enters is not in excess of the amount that just suffices to burn the carbon vapor between the carbons, no carbon deposits are formed, no soot is set afloat, and the life of the carbon is prolonged as much as practicable.

Since the space within the inclosing globe is quite restricted, it is important that the carbons used be of as pure carbon as possible, so that but little residue will remain to be deposited in the glass during the run and obscure the light. The avoidance of any considerable percentage of iron or other metals whose oxides are of dark color or dense and opaque is, of course, imperative. Since carbon itself burns into gaseous oxides which escape, and may be said to be unique in this respect when its very infusible or refractory character is considered, it will not be likely to be replaced in inclosed-arc lighting, in whole or part, by any other material. The introduction of inclosed arcs has, in consequence, forced the manufacture of exceedingly pure carbons, while the other conditions have rendered necessary a great uniformity of texture and density, together with accuracy of form and dimensions. Those who can look back far enough will remember the early carbons with their irregularities, and the considerable percentage of ash contained, and will therefore be able to appreciate the present high standard.

Along with this came the possibility of using the type of mechanism, now so common, in which the carbon itself is fed by the clutch directly instead of being held by a carbon-holding rod, which rod is acted on by the feeding clutch. The possibility of doing this depends on the mechanical perfection of the carbons as to size, regularity of form, straightness, etc., and is favored greatly by the comparatively infrequent feeding action of the inclosed-arc carbons owing to the very slow combustion. The force of this is seen when it is stated that the rate of burning may not exceed five or six per cent of what it is with the open arc. Back in 1885 the Thomson-Houston Electric Company put into operation in Gloucester, Mass., a circuit of about 50 carbon-feeding lamps, but their use had finally to be discontinued owing to the irregular form, size and quality of carbons then available. It is interesting to note that the demand for these lamps arose from the prevalence of low ceilings, calling for a shortening of the lamp, which shortening, as finally accomplished in the modern inclosed-arc lamp, has been attended with improvement of design and artistic effect impossible with the ungainly length of the open-arc carbon-holding rod type. The circuit of lamps above mentioned was, I believe, afterward replaced by a series of short double-carbon lamps with the usual brass holding rods and using short carbons instead of the standard lengths.

With the inclosed, as with the open arc, most of the light comes from the heated ends of the carbons and some from the arc frame itself. The latter portion is not pure white, but is strongly tinged with purple. The same is true of the open arc; but not to the same extent, since the arc flame is shorter and contributes a much smaller portion of the total light. To correct the purplish tint of the light, the inclosing globe is now generally made of glass tinged with yellow, or, rather, glass that has a strong absorption for the blue or violet rays. The glass employed is also generally a thin opal, which, though it causes loss of some fraction of the light by absorption, is still of great benefit in improving the distribution and increasing the apparent steadiness of the arc. When the arc moves about between the carbons, the amounts of light emitted in the various directions change relatively to each other, and this is true to a decided and disagreeble extent when inclosing globes of clear glass alone are used. With the opal glass so near the arc, the globe becomes itself so highly luminous, in virtue of its diffusive power, that it blends or smooths the irregularities of the arc emissions, receiving, as it does, the light of the arc in *any* direction and diffusing the same in *every* direction from itself.

A feature of the arc as inclosed is that the shifting of the arc is generally much more slow or deliberate, so to speak, as compared with the open arc, and the protection from wind or drafts of air further conduces to its steadiness.

The conditions that the inner globe must stand without cracking or discoloration are certainly severe, and call for the best exertions of the glassmaker and glassworker. The temperature changes are great and sudden, while the gases within the globe are of a reducing character so far as oxides of lead and tin are concerned, these being normal constituents of some of the best glasses for withstanding sudden temperature changes. An ideal material for these globes would be fused quartz if it could be worked cheaply enough, for it withstands the most sudden heating or cooling without cracking and can not be softened except at the very highest temperatures, far beyond ordinary furnace temperatures.

The economy of light production in the inclosed-arc lamp can not be expected to approach that of the open arc, and for several reasons. For a given energy in the arc the current is smaller and the arc flame longer with higher voltage. This means that more of the energy goes into the flame, as compared with that which heats the carbon ends. The crater surface is therefore smaller, and as the arc flame itself is a poor source of light as compared with the hot solid carbon surface, the increased arc length in the inclosed arc contributes but little to the illuminating power. Moreover, the surrounding glass globe invariably absorbs a percentage of the light, which increases during the run owing to the partial obscuration of its walls by partially opaque deposits. It is fortunate that these deposits are nearly all on the cap and upper part of the globe, and that as the arc burns down in the globe it comes opposite to those portions of the walls most free from deposits. Were it not for these conditions, the defect mentioned would be more palpable. Considerable attention is now being given to the introduction of refractory substances into arc carbons for the purpose of providing solid matter or fumes in the arc flame itself.

This gives rise to a condition similar to that of an ordinary candle or gas flame in which the particles of soot heated by the combustion constitute the substantial light-radiating surface. When the gas flame does not smoke, these soot particles are completely oxidized or burned to carbon dioxide in the upper part of the flame. Increased efficiency of the arc flame may be, in fact, the result of the introduction of refractory fumes or smoke. The arc then becomes a highly luminous flame with the solid particles carried in it heated to an exceedingly high temperature. Such an arc must be burned in the open air and provision made for catching the smoke or fumes, or their escape may be neglected, as when such fume arcs are used out of doors. It is not probable that any material will be found that, like the carbon particles in an ordinary luminous flame, will burn into invisible gas on leaving the arc after performing its function of having been made intensely incandescent while immersed in the arc flame. Until such material be found, the application of the principle to the improvement of inclosed-arc lights is, of course, out of the question. Another way of improving the efficiency is to substitute for carbon vapor in the arc some substance which at high temperature and in the state of vapor gives a bright spectrum containing light of nearly all colors or wave lengths. But as these, so far as known, give rise to smoke or fumes they can not be employed in inclosed arcs and are, therefore, outside of the scope of the present paper.

From the above brief discussion it would appear that effort should be directed to increasing the purity of the carbons used with inclosed arcs, for bettering the results. The lower efficiency in relation to the open arc is shown to be unavoidable, but must be taken as compensated for by the longer burning without retrimming, lessening the cost of carbons as well as the labor and inconvenience.

The characteristics above pointed out are, of course, shared by inclosed arcs whether used in series on alternating or direct circuits, or used in branches from constant-potential mains. The introduction of the inclosed-arc lamp, however, may be said to have been of the greatest value in the extension of arc lighting upon incandescent lamp circuits in parallel. Still more recently they have lent themselves most effectively to the employment of alternating currents in arc lighting from constant-current transformers, particularly for street lighting. But these matters are now so familiar that it is needless to dwell upon them here.

DISCUSSION

THE PRESIDENT: I will ask Mr. Ryan, before having any discussion on the paper just read, if he will kindly answer Mr. Bean's question on the previous paper a little more fully.

MR. RYAN: I believe Mr. Bean's question was on the relative lighting distance of large units *versus* small units. If we take, for example, 4.4-ampere lamps as compared with 7.5-ampere, we shall require for a given illumination midway between lamps 14.85 4.4-ampere lamps per mile or 10.68 7.5-ampere lamps per mile. Assuming series alternating lamps, the expenditure of terminal energy would be 4,235 watts per mile for the former and 5,180 watts per mile for the latter, thus effecting a saving of 945 watts per mile for the same illumination midway between lamps—building reflections neglected. Further, for the same expenditure of energy per mile—namely, 5,180 watts—we should have 18.17 4.4-ampere lamps against 10.68 7.5-ampere lamps; in other words, we should have approximately 18 strongly illuminated areas against 11. The saving in energy of watts per mile for a given illumination midway between lamps is based purely on the effective illumination, and has no reference to local conditions or greater initial cost for the larger number of small lamps that would be needed as compared with what would be required if the larger units were employed.

Again referring to my statement in regard to the variation of the light of so-called four-ampere lamps with half-inch carbons, I would state that the variation mentioned takes place when the lamp is equipped with the ordinary opalescent globe. It would require a dense globe to balance such a light satisfactorily, but this would reduce the efficiency very much. By using carbons of smaller diameter you not only reduce the variation in the light due to the wandering of the arc, but there is less surface to cool the crater by conduction. A large mass of carbon chills the edge of the crater, which results in a reduction in efficiency.

MR. WIRT: What size of carbons do you recommend?

MR. RYAN: Three-eighth-inch.

MR. WIRT: I think the answer to Mr. Bean's question is like Mr. Hallberg's computation in regard to the lamps on Fifth avenue; you have not allowed for the extra cost of lamps and current.

MR. RYAN: I made the statement that my remarks were based entirely on my point of view; purely the lighting point of view. I do not want the association to forget about the number of lamps, transformers, circuits, and so forth. We have gone into the question of low-current lamps for street lighting, and we can not see much in it. It is establishing a new standard that I think is of doubtful value to either the central-station people or the cities. The efficiency of illumination is reduced when you allow for extra cost of supplying current.

MR. LIEB: Is it not a fact that in addition to the mere question of lighting values quantitatively—that is, so many candles per square foot—you must take into consideration also the general effectiveness of the illumination, its brilliancy, which is a question not touched on here? In other words, if you should put the same amount of candles per square foot on a street with incandescent as with arc lamps, would you not get, as a whole, much more effective street lighting from the arc lamps?

MR. RYAN: I think you are quite right. The reflection from the buildings is a very important consideration, and for this reason it is still questionable how low a unit will be practical, particularly in the congested part of the city where the building reflection is of so much importance. The theoretical arguments based on the illumination measurements of lamps in an open field will stand for surburban lighting, but will of course be more or less modified for city service.

Mr. Wirt: Suppose you have incandescent lights—can you not get a higher lighting value per square foot directly on the street? I think we should not lose sight of the fact that when you go to small light units you place it in the power of the Welsbach people to say that they can give you the same light, or more, per candle-foot. I think there is some distinctive advantage in maintaining large light units; 6.6-amperes is the minimum that should be used.

Mr. Ryan: I am of the opinion that a four-ampere lamp is practical, but do not think we can go below that. When I say four-ampere arc, I mean four amperes actually in the arc. For series work with differential lamps this would mean about 4.4 amperes in the line—varying between 4.3 and 4.5 amperes, depending upon the frequency; the difference, of course, being taken up in the shunt coil. I think we should not be far astray in placing the minimum line current at 4.4 amperes.

Mr. Bean: Do you mean from a financial or from a purely lighting standpoint?

Mr. Ryan: Purely lighting.

Mr. Bean: There are a few of us who are looking after the financial end of the matter.

Mr. Ryan: I leave all varying points of local conditions to people who have to do with the financial side. I stated that my remarks were based on the lighting effect measured with the photometer, luminometer, and other instruments. The financial considerations would in many cases, of course, more than offset any advantages I have mentioned for small units from a purely lighting point of view.

Mr. Williams: To what lamp does Mr. Ryan allude in speaking of the 4.4 amperes?

Mr. Ryan: To the series alternating.

Mr. Williams: There seems to be a conflict between the paper and the verbal statements. I understand the paper to be on the 4.4-ampere lamp.

Mr. Ryan: The paper is on the 4.4, 5.5, 6.6 and 7.5-ampere series alternating lamps. The number of lamps per mile, as previously stated, is governed to a great extent by established location, distances between cross streets, length of blocks, and other local conditions; nevertheless, the economy and the illuminating value of the small units are well worthy of consideration. While with constant arc voltage the candle-power of an arc lamp increases in proportion somewhat more rapidly than the watts, the lighting distance increases only as the square of the candle-power. It is therefore theoretically more economical to work with lower-efficiency arcs at short distances than with a high-efficiency arc at a long distance Of course these arguments do not apply to interior lighting, where distance enters far less into consideration.

THE PRESIDENT: We should be pleased to have Mr. Hallberg close the discussion.

MR. HALLBERG: It is true that I did not recommend the four-ampere series alternating arc lamp to the city of Cincinnati. The Board of Legislation of Cincinnati furnished the specifications for the lighting of the streets and alleys of Cincinnati, and these specifications called for four-ampere inclosed-arc-lamps, consuming approximately 275 to 300 apparent watts each, preferably of the series alternating type. When I was called into consultation the city had already awarded the contract for street lighting to the Cincinnati Gas and Electric Company, and I have been informed that that company had practically placed their order for the apparatus. I could not, therefore, claim to be the originator of the four-ampere series alternating inclosed-arc street-lighting system so far as the Cincinnati installation was concerned, although I was probably one of the first in the business to appreciate the advantages of this system and to design suitable apparatus for it. The four-ampere series alternating street-lighting system was new and unexploited at the time the Cincinnati Gas and Electric Company placed their order for the new street-lighting apparatus and lamps, and considerable credit is due them as well as the manufacturers of the apparatus for the careful and successful manner in which this large proposition has been handled, and I hope that this convention will be benefited by the foregoing descriptions and explanations of the Cincinnati plant. Mr. Lieb seems to think that the general effect of the illumination from the 7.5-ampere lamp is more impressive and satisfactory, and that the benefit of reflected light from buildings and surrounding objects would be greater with the 7.5-ampere system than with the four-ampere system. I believe Mr. Ryan concurred with Mr. Lieb in this. Regarding this subject I would say that my experience has been that since the reflectors were removed from the Cincinnati four-ampere lamps, the benefit of reflected light has been noticeable, but on account of the dense atmosphere and dark buildings in Cincinnati the benefit of reflected light from buildings is rather limited. I have already stated that the Cincinnati Gas and Electric Company received from the city $72 per year for each four-ampere arc lamp, consuming approximately 250 actual watts at the arc. Previous to the installation of four-ampere lamps the city paid something less than $100 per year for each 9.6-ampere open-arc lamp, consuming approximately 490 actual watts at the arc. At the present rate the lighting company receives $144 for two four-ampere arc lamps consuming about 500 actual watts at the arc, and I doubt very much if the city would pay more than $100 (which was approximately the price paid for each 9.6-ampere open-arc lamp) for each 7.5-ampere inclosed-arc lamp, which would consume about 450 actual watts at the arc. In view of what I have already stated, it seems to me that the Cincinnati Gas and Electric Company have the best of the proposition from a business standpoint, as the interest and depreciation on the extra number of lamps, poles, cables and fixtures required for the four-ampere system would probably cost them only a small part of the additional revenue acquired from the increased number of lamps at four amperes. Few Cincinnati citizens objected to the removal of the high-candle-power lamps, but, due to the increased number of lamps, so many more people were satisfied, that the objections to the new system were soon overcome, and I believe that the Cincinnati method of street lighting is now satisfactory to almost everybody. The commercial success of the apparatus and the lamps has been so satisfactory that the city has ordered 1,200 more of the same kind of lamps installed in new territory. The four-ampere system is a complete success in Cincinnati, and it is for each individual company and the citizens of a city to decide whether or not they will adopt a four-ampere lamp.

THE PRESIDENT: I will appoint the following gentlemen as a committee to audit the accounts of the treasurer: Mr. Walter M. Anthony, of Chicago; Mr. N. F. Brady, of New York, and Mr. A. P. Lathrop, of St. Paul.

(The meeting then adjourned until Wednesday morning.)

ORDER OF BUSINESS

WEDNESDAY, May 27th, 1903.

THIRD SESSION, 10.15 A. M.

1. Paper—"The Young Engineer in the Electric Light Plant." By CHARLES F. SCOTT

2. Paper—"Tactful Relations with Customers." By JOHN W. FERGUSON

3. Paper—"Relations with Employees—Benevolences, Insurance, Pensions." By ARTHUR WILLIAMS

4. Paper—"Light and Illuminating Engineering." By W. D'A. RYAN

FOURTH SESSION, 2.10 P. M.

1. Paper—"First Aids and Appliances." By Dr. J. D. McGOWAN

2. Paper—"Steam Turbines." By PROFESSOR WM. LISPENARD ROBB

THIRD SESSION

The meeting was called to order by President Ferguson at a quarter after ten o'clock.

THE PRESIDENT: Before beginning the programme I will announce the appointment of the committee on nominations: Messrs. Samuel Insull, James I. Ayer and Charles R. Huntley.

Secretary Davis announced the appointment of the committee on the president's address, as follows: Messrs. Henry L. Doherty, Charles L. Edgar and H. H. Fairbanks.

THE PRESIDENT: Gentlemen, we have with us this morning one who is so distinguished that he hardly needs any introduction. I have the pleasure of calling on the president of the American Institute of Electrical Engineers, Mr. Charles F. Scott, who will read a paper entitled "The Young Engineer in the Electric Light Plant."

Mr. Scott presented the following paper:

THE YOUNG ENGINEER IN THE ELECTRIC LIGHT PLANT

Within the past dozen years there have sprung up all over the country an innumerable number of central stations, large and small, upon which the electric lighting and power and the street-railway interests depend. These systems employ a great variety of machinery and electrical apparatus, much of which is of types which have come into use or have been greatly changed and developed during the past few years. Much of this apparatus requires special or technical knowledge for its intelligent care, and experience is necessary to direct properly its operation as a system.

What are the necessities and the requirements for special and technically trained men to meet these new demands? What qualifications should these men possess? What opportunities are open to them?

Men who are operating stations have received their training in one or two schools, either the school of experience pure and simple, or the technical school, often supplemented by experience. In the past dozen years a very great change has taken place in technical graduates, both as to quantity and quality. There is also a change in the estimate of their value in practical work. The manufacturing companies have been in advance of the operating companies in appreciating their value and utilizing their services. I can easily recall the time when a college education was counted rather against the man who applied for work with a manufacturing company. Now the output of the electrical courses of our technical schools and colleges is not equal to the demand.

The Position of the Local Company—An operating company should certainly have at hand men who understand the apparatus which it uses and who are competent to direct its operation. Not only this; they should have the technical and the general knowledge which will enable them to take a broad view of their work. They may get certain results; these results may be considered satisfactory, but they should know how much better the results might be and what to do to secure such results. If the entire direction of a local company is in the hands of men who have grown up with the business, there is danger that things may get into a rut and continue there.

A central-station property should have good technical supervision and direction. Its manager should preferably be a man of general engineering knowledge and breadth; he should be a man who has come up through the ranks, so that in his executive capacity in directing work and directing men he has of his own knowledge a definite conception of what he is dealing with. It is not enough for an operating company to have a man who knows only how to run certain machines. That may do for the attendant in a substation or for a dynamo man, but something more than that is needed in the man who is to direct the policy and the development of a system.

There is apt to be a false tendency to economize which rates brains too cheaply and fails to recognize and to advance the intelligent young man. Local companies should appreciate the value of a good man who can check up things generally, who can keep systematic records of operation and see that his apparatus and his methods are up-to-date. They should understand that this is the kind of service for which they should pay and that it is a most valuable investment. A high salary to a good man is soon repaid.

Instances readily occur to those acquainted with central stations in which the lack of proper knowledge has been very expensive. In discussing the value of intelligent men in a central station, a gentleman of wide experience cited this case: Gas engines had been installed in a certain plant and had operated satisfactorily for a very considerable time. The young college man who was in charge was not advanced by the company, so he advanced himself by going elsewhere. The gas engines fell into the hands of an old-time engineer, and it was not many months before they were relegated to the scrap heap.

Another gentleman called my attention to a plant which had gone from bad to worse. Its poor service had encouraged competition, and it had passed from the hands of its original owners at a sacrifice. The direct cause was the bad service given by the dynamo, which had repeatedly burned out. It further appeared that the difficulties with the dynamo, the service and the company itself all followed from an improper connection between the dynamo and the circuits by which the dynamo operated under abnormal conditions.

In a certain lighting plant, which has been running along with fairly satisfactory results, the helm was taken by an energetic college man. He investigated transformer losses; he investigated meter operation. He finally overruled the apathy of his directors, and replaced transformers and replaced meters. During the July following the change, the energy registered by the meters was 45 per cent more than in the preceding July, although the energy generated was 15 per cent less. Before the change, the average for a year showed over three kilowatts generated for each kilowatt sold, while, for a year following the change, the kilowatts generated were 1.52 for each kilowatt sold.

Qualifications Necessary in the Engineer—The central-station system is not a simple one. All of its elements have been developed by experts, and some knowledge of their design, construction and operation should be possessed by the man who is placed in charge of them. Let us consider for a moment the many elements which enter into such a plant. There are boilers and engines with their accessories, there are dynamos and exciters, there are switchboards with switches and safety devices, and indicating and measuring instruments; there are pole lines and underground cables, there are lightning arresters, transformers, meters and lamps, including incandescent, arc and Nernst; sometimes there are rotary converters and storage batteries, and there are motors of one type or another applied to various kinds of service. It is appalling to contemplate all the things which the engineer should know. He not only needs to be a steam engineer, an electrical engineer, and an all-around electrician, but in many cases he may have to do with hydraulics and with gas. Whether his company is in competition with a gas company, or whether it is operating a gas company, or whether it uses gas engines, its engineer needs to be something of a gas engineer. He needs to know something of illumination in order to indicate the kind of lighting and the amount and arrangements best suited to specific places. He needs to know what can be done with electric motors. His knowledge must extend beyond the motor itself; he should be able not only to advise prospective customers as to the kind of motor to use and how to apply it, but he should be on the lookout to advise ways and means of creating a market for power, and thus to increase the output and the load factor of his station.

It is obvious that the ideal engineer, completely developed in all the lines of his possible activity, is a scarce article. Intelligent experienced men are rare, and they command a higher price than the ordinary station will pay. The type of man for the average central station is the young man who has a good foundation and has the power to develop. The man who has a good, active mind and a sound theoretical basis, with even a small measure of practical experience, is capable of dealing with new questions in an intelligent way. One of the differences between the old-time practical man and the young educated engineer is that the former is capable simply of doing over and over what he has done before, while the young man has a power which enables him to take up new problems in a definite, intelligent way. He must be alert and resourceful, but not too inventive. There is a type of originality of the topsy-turvy sort, not tempered by knowledge and judgment, which is as dangerous in the central station as it is elsewhere. He must be able to use the means at hand, to adapt standards to particular requirements rather than to demand that which is special. While a broad college education or a purely technical training is of great value, they are not the necessary and the sufficient qualities of the engineer. The essential thing is the man himself, his native ability and his power of development and of adapting himself to his surroundings and his work. He must have tact and a large measure of horse-sense. He must be able to deal with men as well as with things. The man who has these qualifications may overcome his handicap in not having the special education, although that education is usually of the greatest value. We will probably find, if we examine the ranks of the successful station engineers, that as a rule they are technically trained men who have had their first years of practical training in a manufacturing company. It is a mistake for a graduate to take office work at once. He needs practical work, with overalls and grease and dirt. The apprenticeship courses afforded by the large manufacturing companies are in effect post-graduate courses in practical engineering. A few years' experience of this kind gives the young man a wider knowledge and experience with apparatus than he can obtain in the average station, and it therefore gives him a broad basis on which to build. The man who goes into station work without a technical education, or who goes directly from school to a station, is apt to become narrow and to get into ruts, unless he has exceptional ability and energy. Are there not men of fair ability in central-station work who seem to grow narrower and smaller year by year? A young man in the employ of a company in the far West made it his business to go East each year at his own expense in order to see the latest electrical developments. A friend who was tending dynamos remonstrated on account of the large expense which he was incurring. The young man, however, found that after each of several trips East his salary was raised, and that the increase soon covered the expense of the trip. His adviser still has the same job.

Opportunities Open to Young Engineers—The central station has taken an important place in modern affairs, and the rate of development and extension which has been going on constantly for many years promises to continue. The variety of engineering work involved affords unusual opportunities for engineering ability There is no longer simply the problem of making things run, but questions of efficiency and economy are assuming new importance. In connection with station management there are demands for ability in other lines which a man with engineering instinct and abilities is often well qualified to meet. There is executive administration in the company itself; there are commercial dealings looking toward expansion of the company, many of which can be best handled by the man who is technically familiar with the plant from an engineering standpoint, and who has engineering training, combined with tact and good judgment. Experience in a small station should qualify a man for usefulness in a larger station or for general engineering work. A man who has charge of a small plant has opportunities for broader development than the man who is a small part of a large organization. In the former he has responsibilities in a wide field. In the latter his duties are usually restricted within a limited range.

The young man who intends to make a success of himself as a central-station engineer must be wide-awake, studious and progressive. He should not only know his own plant, but he should know what others are doing, what methods they use and what results they obtain. He, in turn, should contribute from his experience for their information and assistance. It is not enough to know one's own troubles—he needs to know how others overcome their troubles, for he may soon have need of the same remedies. He should be in close touch with electrical engineers and electrical work. He should take part in local engineering societies; he should learn to state his ideas and to impress them upon others. He should learn to think on his feet. He should be in touch with the active and the progressive element in his profession. Meetings of associations such as this one of the National Electric Light Association afford great opportunities. Young men will do well to join the American Institute of Electrical Engineers, and get in touch with its men and its work.

Several years ago a young man in the employ of a railway company asked permission of the manager to attend at his own expense a meeting of the Street Railway Association. The permission was granted. The manager himself decided to go also, and was joined by two other officers. When they returned, it was agreed that they had all had a profitable time, and the young man was asked to hand in his expense account, which was paid by the company. This incident is full of suggestion, not only to other young men, but to other companies.

I want to emphasize again a point which I have brought out a number of times recently, namely, the great work and the great responsibilities which rest upon the electrical profession. The vast interests and the enormous capital which are dependent upon the central station have been developed within a very brief space of time, and have shown a wonderful activity in the evolution of apparatus and methods and systems which were entirely unknown when many of those present entered the electrical field. The rate of increase is rapid, more men are needed, more men will be needed, and it should be the endeavor of the National Electric Light Association as a whole, and of its constituent companies as individuals, to do all they can to promote the development of the best apparatus, the best methods and the best men.

DISCUSSION

The President: Gentlemen, you have heard the able and interesting paper of Mr. Scott; it is now open for discussion. I suppose Mr. Scott has covered the field so thoroughly that there is hardly anything more to say; but if any one here would like to discuss the paper we should be glad to hear from him.

Mr. W. B. Jackson (Madison, Wis.): I should like to say a few words in connection with the paper Mr. Scott has just read and to present a phase of the subject that I think is very apt at the present time. I think I can speak from the standpoint of one of the younger engineers, and fully emphasize everything Mr. Scott has said in his paper. There is one point that impressed me especially, which was brought out very beautifully in the paper, and that is the necessity of a broad knowledge on the part of the electrical engineer. As has been said by the writer of the paper, the electrical engineer can not be simply an electrical engineer; he must be an electrical engineer, he must be a mechanical engineer—at least must have all the broad principles of a mechanical engineer—and in the present day he should go one step farther and have a general knowledge of hydraulics, which is becoming so important a factor in electrical engineering work.

To come to the young engineer more particularly, the point was brought out that the young engineer must know what overalls and grease and dirt are; but we should go one step farther and bear in mind that the young engineer who goes into the dirt with his overalls and comes out and allows that dirt to remain upon him, loses his position; he drops back into that of a mechanic, or dynamo tender, or engine tender. It is the young engineer that, as has been said, can think on his feet, jump into the work when necessary, get himself dirty from head to foot and come out of the dirt as clean and fine-appearing a man as though he had never been in it, or even a better appearing one—he is the man who will be successful. Any one in the station is willing to follow such a man as that to the ends of the earth, and such a man as that makes a good impression upon every man for whom he is working.

I have never been connected with the training of young engineers, but have been intimately interested in such work, and I have been impressed and pleased with the tremendous efforts that are being made, by at least some of those who are training the young engineers, in teaching the man the necessity of being a *man*, and a well-rounded man, as well as simply being an electrician. The man who is complete, who has knowledge of electrical engineering, has knowledge of the general principles of mechanical, civil and hydraulic engineering, and has the manly qualities also, presents the difference between what we may call an electrical engineer, truly, and the man whom we shall have to call an electrical mechanic. The fact that not so very many years ago a man who knew a little of engineering and a little of electrical work made an excellent person to take charge of an electric plant, does not appear in the least at the present day, and that is the reason why we should so fully appreciate this paper that has been read before us this morning.

THE PRESIDENT: We should be glad to hear from some others on this subject.

MR. GILCHRIST: I believe that the young man who wishes to make progress in the central-station business to-day should be very careful to see that he has a very broad grasp of the business. Especially in the smaller companies, a man of the class that Mr. Scott describes and wishes to have developed is likely at a very early period in his career to be in an important position in the company, both as regards the purely business end and also the engineering end. I think that, so far as I have been able to judge, the engineering schools that are preparing men to take positions in central-station companies should give more prominence to the business end: contracting, accounting, the invested capital, the basis on which the companies are formed, and the proper charging of all investment costs as against operating costs, to enable the young manager to determine what the property is doing and whether or not it is doing as it should. I think there is a tendency on the part of the technically educated young man rather to ignore these ends of the business, feeling that the all-absorbing part is the mechanical and electrical part. We will grant that it is very important and that the engineering work demands a class of education that can not be picked up, can not be obtained practically, but must be acquired in a technical school, whereas the business end may be picked up; but preparation to handle the business end should not be ignored, because that is certainly as important as the other.

THE PRESIDENT: The remarks of Messrs. Jackson and Gilchrist are very appropriate, and we should like to hear from some other business men on this subject, giving us the business man's idea of the young engineer in the electric-light plant. Will Mr. Charles E. Hay, of Springfield, Ill., give us his views?

Mr. Hay: I did not hear the paper, and am very sorry that I did not; but in a general way I think it important to have the young engineer qualify fully to meet all the requirements of his position, just as it is important to have the rim of the wheel strong enough to carry the load. In my opinion, it is important for the success of any electric-lighting plant to have the mechanical engineer, as well as the electrical engineer, well trained.

The President: Mr. Ayer has had considerable experience in all branches of the business, in the technical and the purely business side, and we should like to hear from him.

Mr. James I. Ayer (Boston): Mr. President and gentlemen: I do not know that any extended remarks can be made on the subject without covering much of the ground that has already been traversed. I think that as central-station men we all appreciate the value of the engineer. We also appreciate the value of thoroughness in all the various branches of engineering, as well as in the electrical; but it has been quite a conspicuous thing, I think, to most employers, that all we hoped for from our technical schools has not developed. A number of companies have had occasion to undertake to break in the young engineer and they have had many disappointments, due to the wrong idea with which the graduates have viewed the situation. They like to graduate from the school into an office, into an engineer's office; into the office end of the business rather than into the mechanical end, the really practical end. I think most of us realize that the engineer's training has only been started when he leaves college. He has had a fine preparation to fit him to be an engineer, but for the practical side of the work—the actual mechanical work, coming in contact with the real things themselves—he should have four or five years of work in the mechanical part of the business, during which time he should disregard in a large measure the fact that he has been trained as an engineer, and should go to work as a mechanical man to learn mechanics practically; to learn his trade, in a word, and to acquire what will prove to be the most valuable part of his education. He will then be fitted to become an engineer, and if he is a man of average ability he will show up with something more than average ability in his life's work, as compared with the engineer who leaves college and takes up work in an engineer's office. We must know engineering as we know our alphabet—know it without having to dig it up when a problem strikes us. The fundamentals must be at our fingers' ends. The young engineer can not be qualified to best meet the conditions unless he actually handles the machinery in practical use and gets such knowledge. I believe this is an important point and should be emphasized, because it is within 10 years—hardly longer—that the college has graduated electrical engineers, and, in fact, to any extent mechanical engineers, and the necessities of the situation are not fully recognized by many. I am sure that in saying this I only reiterate the experience of most of the gentlemen in this audience. The young engineer does not appreciate it in that way. I have employed a dozen graduates, have tried some for a year and some for two years, and have been unable to get results that were satisfactory to me, and it has been a great disappointment, simply because they began at the wrong end. They wanted to start in the office, and that is not the place.

MR. LIEB: The paper presented by Mr. Scott is hardly one that admits of a general discussion as to the proper education of the electrical engineer, but I should like to say just one word on this subject, very briefly referred to in Mr. Scott's paper. I believe that the proper course to follow to develop the electrical engineer who shall be fitted to assume the responsibility of the technical direction of the electrical enterprises of to-day, is first to develop the engineer—the mechanical engineer—then add the specialization required of the electrical engineer. The purely electrical courses, as they are organized to-day, are apt to develop electricians and not electrical engineers; and when graduates of these courses, soon after graduation, are called upon to handle broad engineering problems, they are seriously handicapped by an insufficient grounding in the general principles and practice of engineering science. The proper course to pursue in the training of the electrical engineer is to give him a thorough course in mechanical engineering, with some electrical work incidental to the course, and then superimpose upon that one year of specialization in electrical engineering. One of the gentlemen has referred to the desirability of broader aims on the part of the engineer. This is extremely important, and it is a matter in which the engineer is apt to be open to criticism; he looks upon the problems that are presented to him from time to time from too narrow, too technical, a point of view, leaving aside the important business relations that the problem may present.

I think, also, that what is perhaps needed in a larger measure in the product available to enterprises requiring engineering assistance is a stronger infusion of common sense. If there could be established a chair of common sense in the faculties of some fine technical schools, the incumbent would find a wide field for cultivation.

Another point that Mr. Scott has touched upon is the deficiency of the young engineer in being able to present his ideas properly in a clear, concise form, so as to convince his principals of the strength and cogency of the views that he presents. There is nothing that places the young engineer at so great a disadvantage as a half-digested, loosely-phrased report, lacking in clearness and conciseness. It should be the aim of the young engineer specially to qualify himself to make a strong presentation of the subject of his reports, so as to impress his superiors with the reasons for the faith that is in him.

PROFESSOR H. E. CLIFFORD (Boston): As one who has been for a number of years connected with the training of young men for the electrical engineering profession, I have been much interested this morning in listening to the expressions of opinion on the proper training for an electrical engineer. I think it would be of the greatest advantage to us who are teaching in the technical schools of the country if we could, from time to time, have from you and other organizations of this character some expression of opinion as to your needs ; as to the failings, as to the deficiencies, of the young men who graduate from our technical institutions and who go out to do your work. I have been looking for a great many years for such an expression of opinion, and I must say, with a good deal of regret, that it has not yet come to me. It is easy to criticize the finished product, but what we want to know is the reason why that finished product is unsatisfactory, so that we may be able to apply the correction in the making of the product itself. We want to know, while we are training our students, what they are going to need when they go out into the world, and the only way in which we can discover it is for some of us to come to conventions of this kind, or for you to take up the matter and express in formal shape your conviction as to what our technical graduates need.

I was much interested in what Mr. Lieb had to offer in regard to a sound foundation in mechanical engineering for an electrical engineer. I heartily concur in his opinion, and it is precisely that sound foundation that we try to give our men at the Massachusetts Institute of Technology. I appreciate what he has to say in regard to the chair of common sense, but am inclined to think that common sense, on the whole, is born, not made. It is very difficult to instill common sense into a man who does not possess it or its essence.

You must appreciate that in any electrical engineering training the subjects that are given are selective. In the brief four years that are devoted in most technical schools to the preparation of an electrical engineer, so far as his foundation work is concerned, there is such a vast amount of material that must be touched upon, and this in ever-increasing quantity, that it becomes the province of the governing body of the institutions of learning to decide on just the things that, in this brief time, will best conduce to the future success of the men who graduate. It is for this reason that I say again that I wish we might have some expression from time to time from the National Electric Light Association as to what its members have found lacking in the graduates from the technical schools of the country, to enable them to carry on their work successfully.

With regard to the remarks of Mr. Ayer, I think there is a better attitude among students as to beginning on the mechanical rather than the office side of electrical work after graduation. I am inclined to think, so far as the students with whom I am brought in contact are concerned, that it is due to the influence of the alumni in sending back to us, as they do occasionally, an account of their own experience and of the things that would have made for success in the particular work that they are following. But I think you must all agree that if we could have the opinion from a body of men who are actively interested in the development of the electrical interest of the country, as are the members of this association, as to what qualifications are expected in the graduates, we as teachers should be in a much better, a much sounder and a much happier position in our attempt at forming the successful technical graduate.

MR. W. P. ENGEL (Defiance, O.): I will take only a few moments. We know of cases where young men have started out as dynamo tenders and have become firemen and engineers without technical knowledge. They have been successful in a way. They have been able to keep the plant going successfully financially. They have gone from the position of engineer to that of superintendent, and finally to the ownership of a plant. When a young engineer takes charge of a plant, he is very apt to introduce new things at once. This is a serious objection to many young engineers. In my experience during the past five years I have hired six technical men at salaries of from $125 to $150, given them full charge of the plant, given them three months to study it before they should propose any changes—as invariably every one of them did—and among them I have found but one who said, "I have been through college, but know very little about practical work, and should like to go into the plant to get familiar with all details, and begin as a dynamo tender." That man remained with me, and within six days he said, "I think I can get along with what you have for the present, and we will make as few changes as possible." That is one of the points to be looked into. The young engineer coming out of college invariably wants to do his business from his office; he expects superintendents, to whom he will give orders, and then have the assistants of the superintendents do the work. That kind of man is not successful.

MR. E. F. PECK: There are other points of value to the young electrical engineer outside of his technical training, especially to one that expects to supervise a small central station: First—application. A young engineer should be willing to apply himself at all times to his work, and in case of necessity be willing to jump into the breach, even to the sacrifice of his personal and social engagements. Second—Diplomacy is a very great factor; and one of the first questions generally asked when securing the services of a young engineer is "Can he handle men with tact?" With these qualifications and a good technical training, he will certainly make a very valuable man to any electric-lighting company.

MR. AUSTIN BURT (Waterloo, Ia.): I think it is important that the college graduate, when he goes out of school, should bear in mind that he should not imagine he knows it all. The man that has had practical experience knows more about the every-day operation of the plants than does the college graduate, and the latter will gain practical experience much sooner if he will assume the attitude toward the practical man that, although he is a college graduate, he really does not know as much practically as the man that has had the experience. In this way the college graduate will learn more and get in better touch with affairs than if he started in the other way. I am a graduate of Cornell University, and can say, from my knowledge of inside and outside work, that a sound technical training, backed up with a liberal supply of good, hard, practical experience, is the surest road to a successful engineering career. My technical training at school enabled me to learn faster and to get hold of the cause of trouble quicker than I could had I not enjoyed the benefit of such training, but I have found, too, that the unlettered practical man could *do things* and was always glad to show me all he knew if I could only get on the right side of him. There is no surer way to lose this advantage than to try to make him think you know it all. After all, he may have worked just as hard as you for what he has and he should be respected for it. Personally, I feel like taking such a man by the hand and thanking him for saving me many of the hard knocks he has had.

Professor W. L. Robb (Troy, N. Y.): One thing that has attracted my attention in the discussion is the fact that nearly all the speakers from the central-station standpoint paid a compliment to the technical schools, but they all seem to expect perfection in the young graduate of twenty-one. You can not properly expect that. If you take a man fresh from a technical school you can not expect any more from him than the hospital authorities expect from a young graduate of a medical school. It is only after years of experience that the graduate becomes an engineer, as only after years of experience and practice a graduate of a medical school or law school becomes a physician, in the true sense, or a broad lawyer. You can not get broad-minded engineers in young men of twenty-one or twenty-two years of age. I agree in everything Mr. Lieb said about early specialization; but I think technical-school graduates ought, first of all, to be *engineers*, and after labor and practical experience become electrical, mechanical or civil engineers. Certainly any electrical engineer should have broad foundation, not only in mechanical and electrical engineering, but in civil engineering. Some of the first problems with which he will come in contact, in passing upon the design of structures, strength of materials, etc., are problems that apply particularly to the department of civil engineering.

A thing that has pleased me very much in recent years is the tendency of the different engineering societies to get together, and I hope that object will soon be realized in the Union Engineering Building, in New York city. It seems to me, in thinking over the subject, that the reason why the general public has not recognized engineering as one of the learned professions is that there are too many kinds of engineering—civil, mechanical, plumbing, and other kinds of engineering. I do not believe we should have the same respect for the medical profession or the legal profession if a physician were first an eye doctor, or ear doctor, or lung doctor. He is first of all a doctor, and after that he comes to be a specialist. He refers to himself as a physician—not as an eye or a lung doctor. The same is true of lawyers. A man is first of all a lawyer, and if he attains distinction in any particular branch of the law he becomes a patent lawyer, or a maritime lawyer, or a real-estate lawyer; but he always refers to himself as a lawyer. It should be the same with engineering. A man should be first of all an engineer, and later a specialist, working in that department of engineering to which he finds himself best adapted.

MR. J. S. PECK: In listening to the reading of Mr. Scott's paper, regarding the education of the young engineer, I was reminded of a quotation from an essay of Professor Thomas H. Huxley on "A Liberal Education and Where to Find It." Professor Huxley brings out in this quotation a fact that has not been touched upon this morning, that is, the necessity for training a young man to keep his body in such condition that as a machine it may work at highest efficiency:

"That man, I think, has had a liberal education, who has been so trained in youth that his body is the ready servant of his will, and does with ease and pleasure all the work that, as a mechanism, it is capable of; whose intellect is a clear, cold, logic engine, with all its parts of equal strength, and in smooth working order; ready, like a steam engine, to be turned to any kind of work, and spin the gossamers as well as forge the anchors of the mind; whose mind is stored with a knowledge of the great and fundamental truths of Nature and of the laws of her operations; one who, no stunted ascetic, is full of life and fire, but whose passions are trained to come to heel by a vigorous will, the servant of a tender conscience; who has learned to love all beauty, whether of Nature or of art, to hate all vileness, and to respect others as himself.

"Such an one and no other, I conceive, has had a liberal education; for he is, as completely as a man can be, in harmony with Nature. He will make the best of her, and she of him. They will get on together rarely: she as his ever-beneficent mother; he as her mouth-piece, her conscious self, her minister and interpreter."

MR. ANTHONY: There is another side to the fence in this matter. I think the greatest handicap to the young man's progress in the central station is the attitude of many station managers. Too many managers bottle up most of their information and label the bottles "poison." Until these managers are willing to take the corks out and the labels off the bottles, and let the young engineer get drunk on the contents, we can not complain of the inefficiency of the technical training that the young man receives at most technical schools. They come from many schools well equipped technically, and if you do not give them a chance to display their ability practically it is not their fault. The college people often give them a better chance than the station managers do after the students graduate. The manager's office, the superintendent's office, and everything, should be wide open to the young graduates along the line of giving them necessary information regarding its workings. Take the bookkeeper in and give him some knowledge of the dynamo. The auditor's office should be open to the young electrical engineer, and he should be taken into your confidence, where he will get an idea of the commercial value of the dollar. The point I wish to make is that the station managers themselves too often take an attitude toward the young men that is more of a handicap to young engineers than all the colleges put together, particularly when they keep all the information to themselves.

MR. J. H. ROLLINS (Albion, N. Y.): Mr. President and gentlemen: I consider that Mr. Anthony's remarks concerning accounting are vitally important to small as well as to large-station management. I can only speak from the standpoint of the small-station manager, and I was greatly impressed with Mr. Scott's remark that there is a vast difference between the knowledge necessary in an engineer to operate a small station and an engineer to operate some one part of a large station. There are only a few central stations like those in Chicago, Boston and Philadelphia, but there are thousands of small stations in towns of from 5,000 to 10,000 inhabitants, where the electrical engineer must also be the steam engineer, the hydraulic engineer, the "trouble" man, and everything else; in fact, he must be the whole thing in a small station, and he should certainly have a liberal education. He must also meet the patrons of the company and must therefore have more or less knowledge of business, bookkeeping, accounting, and of all other matters that enter into the operation of a small station. Please let us hear from managers of small stations as well as the great ones.

PROFESSOR W. E. GOLDSBOROUGH (Lafayette, Ind.): I have been interested in what has been said about young engineers. As I come in contact with them a great deal I do not like to let pass the opportunity of presenting a few thoughts that have been brought home to me strongly. Professor Robb has said that engineers should be broad engineers. I think no one will agree with him more heartily than I. I have made a strong fight at Purdue University to have all of the civil and mechanical engineering studies possible retained in the electrical course; but unless a sentiment develops in this country that will give us about two more years in which to educate young men, it will be impossible for us to make them broad engineers and at the same time give them the amount of special electrical training that they will need to meet the demand that will be made on them by the electrical engineering profession. Only to-day I was told of an electric-power station that is being planned to so combine conditions as to have a 100-per-cent load factor and get 90 per cent of the heat out of the coal used. No man can go out and try to do that who is not broadly and technically educated. He must be able to see theoretically much farther than the practical demands of every-day life require. Only the man who can see the ultimate way, the real way, the exact way of doing a thing, can afford to take short cuts. If I know the accurate way of doing a thing I can take a short cut, using good judgment. If I do not know the right way in which to do a thing and then resort to makeshifts, I am weak in my position and am apt to fall into errors that will prove detrimental to the undertaking in which I am engaged.

It is impossible for any man at the present time to round up and fully digest all the knowledge pertaining to civil, mechanical and electrical engineering in four years. *It is perfectly impossible for any man to do it.* In my judgment, the young engineer of the future will have four years of general engineering training all along the lines, and then he should have two years of specialized training.

MR. MCCABE: It seems that this is a sort of experience meeting. Twelve years ago I graduated from a technical school and wrote about 200 letters in seeking a position. I invariably received the answer that my letter had been received and placed on file. I wrote to a friend of mine about it and he suggested that I should not say anything about being a graduate of a college, but tell of my practical experience and of the hard work I had done. I did so, and secured a position. In the 12 years of my experience I found many things in which I was at fault. I learned many things at college for which I had no use afterward. I did not, however, have at college a course in bookkeeping or accounting, which I have needed ever since and which I need to-day. If some of the higher and oftentimes useless studies had been omitted and I had received a course in bookkeeping and modern accounting, I think it would have been better for me; it would be better for most central-station engineers. The station engineer may not need this knowledge as an engineer, but if he is promoted to be a superintendent and finally becomes the manager of a plant, he should have a good knowledge of modern accounting.

MR. H. T. HARTMAN (Philadelphia): In the discussion of Mr. Scott's interesting paper there has seemed to be a tendency to assume that the central station owes something to the young engineer. He is apt to think so himself, and herein lies the root of much trouble. During his college course he has command of his time to a great extent; his work has been of an agreeable nature, and his amusements many and varied. He fully realizes that his advantages have been great, but he is apt to overestimate entirely the value of the training he has received, for the reason that it has been almost entirely theoretical, and there has been no adequate practical test of the actual extent of his knowledge and its availability for instant and effective use. For all these reasons he is likely to think and act as if he were of a little different clay from the rest of humanity, and not entirely amenable to the same rules and the same tests of fitness.

The station manager is apt to think lightly of recent graduates, possibly because he remembers how green he was himself at the same period in his career. He is pretty certain to reject without further examination any applicant who does not look strong and healthy, and he puts the successful candidate at work wheeling ashes or unloading coal, or at some other equally rough and disagreeable job, in order to see whether or not he has sufficient grit and perseverance for a man in his make-up. If the young engineer quits after a day or two, the manager feels, rightly or wrongly, that he is well rid of one upon whom it would have been folly to waste any time and attention.

No lighting company can afford to keep a man who does not earn his pay, and earn it beyond any possible question of doubt. Aside from the fact that every unnecessary expense must be avoided, discipline demands that there shall be no room for even the slightest suspicion of favoritism. No one has much time to spend on the young engineer, and he must learn the business by doing cheerfully and well all the work that is given him, no matter how distasteful, and his training must come partly—indeed, largely—from observation. He must not expect to be transferred from one department to another as soon as he feels that he has had sufficient experience to warrant it. No central station can afford to maintain a school, and he must remember that he must always subordinate his own interest and his own wishes to the good of the company if he wishes for recognition and advancement. He should completely divest himself of the idea that he is anything but a learner, and should avoid even the appearance of a desire to institute general reforms; at least, until he is thoroughly familiar with the conditions. If he talks college, flourishes a slide rule, or does his figuring too conspicuously; if he fails to do thoroughly whatever work he is intrusted with, no matter how trivial or distasteful it may be, or if he is not always ready and anxious to help—he will find his position in an electric-light plant both lonely and disagreeable.

One great opportunity the college man may never have again is that of learning by actual daily contact and association the viewpoint of the men who may some day be under his charge. If he is in the least degree supercilious and patronizing or unduly familiar, he might as well be alone on a desert island so far as this very important part of his education is concerned. The central-station employee with whom he comes in contact is likely to be a high-class man in his own particular work. He will judge the young engineer by his proficiency in the line he knows most about himself, and as he will be doubly critical on account of that college education, it behooves the novice to be modest, as well as extremely careful in all matters relating to the other man's specialty.

In conclusion, I would say to recent graduates of technical schools that if they are willing to spend two or three years at laborer's wages on hard, dirty work; if they are willing to risk much exposure and some danger; if they can patiently endure occasional browbeating and injustice from their social inferiors, then there is a chance for them in almost any plant, and by the end of the probationary period they will have acquired a training that will make them valuable men. If they want to keep their hands clean, and wear their good clothes, they had better try some other line, for the central station can offer only disappointment.

THE PRESIDENT: We should like Mr. Scott to close the discussion.

MR. SCOTT: Professor Clifford has brought out one point that was expressed very aptly by the president of his institute during the past winter. President Pritchett, of the Massachusetts Institute of Technology, gave a talk before an alumni association of that institution. While I was not strictly entitled to be present, I was there as a guest. President Pritchett said he had visited a factory that day, in one department of which he was particularly interested; it was the "returned-material" department. He said that particular attention was given to the things that came back—the things that failed to meet the purposes for which they were designed and failed to perform their proper functions when they went into service. This returned material was carefully investigated to see what the fault was; whether it was some inherent weakness or inherent fault, or a question of misuse. He said he thought it would be an excellent thing if the educational institutions of the country could have a returned-material department. They send out certain material. You central-station managers use material from the manufacturing companies, also from the educational institutions, and President Pritchett thought it would be an excellent plan if the institutions of learning could have a returned-material department, so that they could see in what respects the men they sent out had failed, and why, so that these institutions in the future could overcome the defects in the material they put out, just the same as the manufacturing companies would do. Some of these defects or shortcomings have been brought out this morning, as well as the fact that in some cases the trouble with students, as with apparatus, is that they may not have been used properly.

I began to see during the latter part of the discussion that the paper was probably too optimistic. I have indicated a few of the things that the engineer might do and could do. I think it would be well if we could have more information as to the cost that a good many of these young engineers have brought upon the companies for which they were working, for some young fellows are apt to go ahead without adequate knowledge or experience. Such a case has been cited in the company that started in with a new engineer every year and got a new line of apparatus each year to increase their troubles and expense account. The whole subject is a vitally important one and I commend it to your careful consideration.

THE PRESIDENT: We will now proceed to the next paper before the convention, by Mr. John W. Ferguson, of Chicago, entitled "Tactful Relations with Customers."

Mr. Ferguson read the following paper:

TACTFUL RELATIONS WITH CUSTOMERS

The question of the tactful treatment of customers, while a subject which has probably occupied the attention of individual members of this association, is one that I believe has never been raised to the dignity of a discussion or of a paper read at the convention. The discussions held at the annual conventions have heretofore been mainly on matters pertaining to the purely operating departments of the business. Without in any way deprecating, or wishing to take one jot or tittle of importance from those departments and the technical questions particularly interesting them, I maintain that the time has come when the daily relations of those departments with the public must be considered, and the duties and responsibilities of the purely business departments (so called) should be taken into consideration.

As I am fully convinced that the subject is one in the discussion of which it would hardly be possible to spend too much time—as it is a subject that strikes directly at the life blood, *i. e.*, the income of the central-station company—and as it is a subject that intrinsically affects the standing in the community of the corporation, be it a railroad, a lighting and power plant, or any other form of public service, it is my opinion that a full and ample discussion of the subject must sooner or later result.

To central-station managers, it is a question of the utmost importance. On them devolves the duty not only of defending and advancing the interests of those who are financially interested in the corporation, but, and almost more important, is the duty assigned them as representatives of the franchise rights granted by the body politic, to which body they will be held for a strict accounting.

A question to-day seriously occupying the attention of the public—and one that, if not provided against by the just and tactful treatment of customers, will surely in the near future play an important part in our political life—is that of municipal ownership of public utilities. It is not my intention to discuss the *pros* and *cons* of this issue, but, as you, gentlemen, or most of you, represent such public utility corporations, it is fair to assume that you are opposed to any legislation looking to a change in existing conditions. Then you should show by your methods in operating your companies that you recognize the *limitations*, as well as the privileges, vested in your franchise rights. You should show by your acts your realization of the fact that those rights have been granted by the people, and that they have at all times the right to demand from you an account of your stewardship: that your duties well and courteously performed will disarm criticism, while such duties neglected or discourteously performed will result in a just upheaval that will bring disgrace to you and disaster to the financial interests you are chosen to defend.

The responsible head of any company should therefore see to it that there are placed at the heads of the various departments under him men who will realize the necessity of tactful treatment of those with whom they come in contact. The methods of the various employees will in most cases be found to be in line with the methods of the head of the department, and for this reason ***suaviter in modo***, *fortiter* ***in re***, mildness in method, force in execution, should be the governing principle for all heads of departments in the central-station company. Never losing sight of his duty to the company, though at times the fulfilling of that duty may cause temporary displeasure to the customer, it is always possible so to perform the duty that the minimum amount of dissatisfaction shall result, and this should be the object of the head of each and every department in every company. Of course we all know that it is impossible for the head of the department to look after every detail. He is not a success unless he is a detail man, but that should mean his having his department so systematized as to produce the detail when he may need it. He should therefore surround himself with such assistants, and so impress upon them their duties to the company and the public, both by precept and example, that the tactful relations with the customer may be maintained without jeopardizing the best interests of the company.

From the office boy and the elevator conductor, through all the ramifications in the organization of a great company, up to the president, upon each and every one depend the reputation of the company and its popularity, or lack of it, with the public. The office boy of to-day may be the president of to-morrow; the bookkeeper or bill clerk may later be the comptroller; but this can only be if he so fulfills his duty as to impress favorably the outside public, to accomplish which he must continually strive to maintain the friendly relations of the company with the customer.

The Perfunctory Performance of Duties Devolving upon us never Produces Preferment. Every employee should be ambitious to improve his position in his company. To secure this advancement, he should not be content simply to do his duty, but should strive to do it better than any one else could perform the same duty. It may at first seem that I am now away from my subject. Not so. Much good or much harm may be done the company in the minds of the public by those with whom the public may never come in personal contact. The introduction of the telephone in business life has been at once a great blessing and a great curse. To the acquisition of the telephone is attributable much of the development of business possibilities. This we all know. But unfortunately we also know that to the misuse or careless use of the telephone is due much of the ill-feeling exhibited by the public toward public-service corporations. Too much care can not be exercised by the department manager in impressing on the minds of those under him the necessity of courteous telephone treatment. It is one of the peculiar weaknesses of human nature that we are all more or less prone to adopt, at times, an acrimonious or peremptory tone on the telephone which we would not dream of employing if dealing with the customer *in persona propria*, and this is particularly true of the junior clerk or office boy who conceives an exaggerated idea of his own importance. To school those whose duties bring them into frequent daily contact with the public over the telephone, to be patient, polite and exact, is a task of no small magnitude; but it is one that can not fail to commend itself to the men in authority who carefully study the situation. I do not think I am overstating the case when I affirm that a company's reputation with the general public depends, in the last analysis, upon the spirit exhibited by the company's rank and file as much as upon the influence exerted by its general officers. I am pleased to believe, from my observations, that the time when the employee of a corporation looks upon the public as his natural enemy and treats him accordingly, especially in telephone communication, is rapidly passing away. But in this line much yet remains to be achieved.

Thus far I have dealt altogether with the duties devolving upon the office employees in maintaining friendly relations with the customers. This is, of course, very important. But much more important is the relation to the customer of the contract agent, the inspector, the collector, the meter reader and the repair man. They are the ones who come in daily and close contact with the customer, and on them devolves most closely the duty of maintaining the friendly relations with customers. The repair man may maintain the friendly relations more intimately by carefully attending to his duty, be it the connecting up or cutting off of a customer. I have known men whose primary duty it was to cut off customers for non-payment of bills, who have so performed their duties that not only was the customer not cut off (because he paid his bill), but was made a valuable customer for the company. The meter reader can make himself valuable by his *suaviter in modo*, while answering questions asked by the customer. To say, "If you want to know how much your bill is, go to the office," is one extreme of folly. To say, "Your bill for this month is so much" (not regarding the previous reading), is the other extreme. Between the crow's monosyllable of the first, and the parrot's chatter of the second, the Scylla and Charybdis, lies the road to the "presidency." I have known collectors who so approached customers in demanding payment of a bill that they have not only collected the bill, but left a satisfied customer after they departed.

The inspector is considered by the customer as one link in the chain of his friendship with the company, and much depends upon the tactful manner in which he may tell the customer he can or can not be connected to the station, and the reason therefor. For instance, to speak to the customer in terms that he will understand, is a delicate courtesy, and one bound to be appreciated. Harm may sometimes be done by thoughtlessly expressing one's self in technical terms. To say, "You have no City," may be English to the inspector, but Greek to the customer. It would not consume much more time to say, "It is necessary for you to procure the approval of the city inspection department and pay its fee, and this may be done, etc." But still the amicable relation might thereby be better maintained. To say, "This wiring will not pass city inspection," may be true. It would be more satisfactory to the customer if he were told, not in technical terms, but in good every-day expression—and such is possible—wherein exist the defects that prevent that customer from furnishing his share of the income due to the company.

And now I come to him who can best show the advantage of tactful relations—the agent. The time has passed when the contract agent can be considered as a result of the central station—a something necessitated by the inherent extension of the business. He is now a prominent and necessary factor in the growth of that business. He leads, let others follow. But, because he leads, because he is on the firing line of the progress of his company, greater duties and obligations devolve upon him. To him, almost more than to any other man in the company, appears to belong the right to cherish ambition for advancement. *Honorable* ambition is the right, the duty, of every man. Honorable ambition means the seeking to uplift one's self only by uplifting that body or people through which one seeks to be uplifted. Therefore, while the agent has a greater opportunity, from his daily association with the business world, to find means to gratify his ambition, there rests upon him, for that very reason, a greater responsibility—that he shall so conduct himself and so perform his duties that he will advance the interests of the company he represents.

I can not proceed further on this subject without referring to one custom that has been too common, and must have brought into disrepute the companies where it has been practiced. I mean using the contract department of the company as a catch-all for applicants for positions who are backed up by personal friendship of the officers or by political influence, and by nothing else. I do not mean that men so vouched for are *ipso facto*, incompetent, but unfortunately they too often seek support of this kind because they have not the force or ambition to advance their own fortunes. If such men must be taken care of, let them at least be placed where they will do the least harm.

Gentlemen, take home to yourselves the question of the careful choosing of solicitors. When the coal agent or the man from the oil company calls on you, you will instinctively judge the company by its representative and govern yourselves accordingly. Choose, then, solicitors who do, in the true sense of the word, represent you. Finesse and diplomacy are qualities that every solicitor should cultivate, but *never* at the argue why he is mistaken. It would, of course, be superfluous to remind you that the employees of a corporation who have rendered him his bill, have done so in all honesty and with fair intent; but, gentlemen, it devolves upon the claim agent to convince this exasperated man that no injury has been done him, or that if he has suffered an unintentional harm the company is only too anxious to right the wrong.

The claim man, therefore, should be one who would instinctively and at once be able to judge the character and temperament of him with whom he is to deal. In the majority of cases, I think it is a mistake to try to convince the claimant of the correctness of his bill at the first interview. Rather, I would advise that his complaint should be carefully and respectfully listened to, and then he be informed that a thorough investigation would be made. When this investigation has been made, the claim man should look well into the conditions and satisfy himself that having once taken a position based upon that investigation his ground should be so sure that no evidence could afterward be brought to cause him to withdraw therefrom.

Should the result of his investigation show that an error had been made in the reading of the meter, or in figuring the bill, or in any other way, he should at once hasten to apprise the customer of this fact, state to him the rebate to which he might be entitled, and make the customer feel that the company is grateful to him for giving it an opportunity to rectify the wrong. Where the result of the investigation shows that the readings are correct, and that no injustice has been done to the customer, then I believe he should, as far as possible, seek a personal interview in which he may explain to the customer why the bill appears to be right, and in which he may receive from the customer information which would tend to show the justice of the company's position.

The position of claim agent is a very trying one, but it has its ray of sunshine in that oftentimes the claim agent can afterward point to cases where he has proven to the customer's satisfaction that the bill as rendered was correct; and he will find that that honest contestant, once satisfied as to the company's just treatment, will hereafter not only cheerfully pay his bills so long as they are correct, but will at all times, in and out of season, bear evidence to the fair, just and tactful methods pursued by the company.

Finally, let us remember, gentlemen, that the primary object of our business, as of any other business, is financial advancement. What the citizen needs in our line we must give him; what he thinks he needs, we must find for him; what he is unaware of in his needs, we must show him, and all for the commercial betterment of our city and the financial advancement of our company.

DISCUSSION

THE PRESIDENT: The paper is open for discussion, and we shall be glad to hear from some of our members on this subject.

MR. LEON H. SHERCK (New Orleans, La.): Mr. President and gentlemen: Most central-station managers feel that, owing to their other duties, they have very little time to devote to finding out what the office boy, the telephone boy, the contract agent and claim agent are doing. I recall an incident where an electric company was threatened with the loss of one of its customers and also, perhaps, with a law suit, simply from the careless remark of one of its telephone boys. It seems that the young ladies in the city in question had the habit of fixing up cozy nooks and calling them "dens." The incandescent light was frequently used to ornament these so-called dens. The proprietor of a large restaurant telephoned to the company that he wanted some extra lights put into his house, the particular part being a cozy corner, he being ignorant of the fact that cozy nooks were ever entitled dens. Through an error, instead of a solicitor calling at the gentleman's house, a trouble man was sent, as the telephone boy was under the impression that a case of trouble existed. Some confusion resulted from the trouble man seeing no trouble to be remedied at consumer's premises, and the gentleman in question, not having seen an agent of the company, telephoned to the office to know why his previous message relative to "getting something done" in his residence had not been attended to. He was answered, perhaps a little curtly, by the telephone boy that another man would be sent to fix up his den. The restaurant proprietor became very much offended—not understanding what "den" meant—that his house should be called a den, and it was only after some letters had passed and a personal call had been made by the head of the contracting department that the matter was straightened out.

I simply bring this to your notice to show how these little things seldom come to the attention of the manager of a central station unless a letter is written to the company, stating the customer's grievances. I think you all know how very few of our customers will take the time to write us a letter stating that our employees have acted thus and so. Most of them will simply say, as perhaps they sometimes say of our company, that it is an octopus with so many million dollars' capitalization, and that when another company starts up they will give their business to the new company.

There is a point in this paper that I believe was touched upon by Mr. Gilchrist in a previous discussion. On page 291 it is said, "Take home to yourselves the question of the careful choosing of solicitors." I would say one word on that subject, and that is, I think the greatest care should be exercised in choosing the head of your soliciting department. I believe it is almost necessary to-day to put in charge of your contract department a man who has some knowledge of engineering. I do not mean to say that you are to employ an expert engineer as your contract agent, but you should have a man who has some knowledge of inside wiring, some knowledge of motors and dynamos, and some knowledge of how to deal with the question of isolated plants and their closing down, so that the owners of the plant might be persuaded to buy current from the central station. As a gentleman remarked in a previous discussion, "Central-station managers do not realize the importance of having men of that kind around them." I recollect distinctly my own experience some seven or eight years ago, when I made application to one of the large companies for a position. The superintendent asked my qualifications and what I had done. I told him I had spent some six years in a technical college and had taken two degrees—Bachelor of Science and Mechanical Engineer. He looked me over in a gruff sort of manner and said, "Young man, I shall not let that count against you." I believe now that a technical education counts very much in favor of a young man. Do not put a man in this position because he is prominent in social circles, or because he is a sort of hail fellow well met; put a man in who can discuss with the proprietor of a large store or hotel the difference in cost of running his own system or taking current from the electric company; and he should be able to show that the central station is able to supply current cheaper than it can be supplied by the independent plant, if such is the fact. He should, of course, always tell the truth. He should know what part of the underground system is loaded, and should be able to say whether or not extensions would be profitable in either overhead or underground districts. He should have some knowledge of these matters without consultation every time with the engineer. When it comes to special work, such as the extension of aerial circuits in different districts, or running the underground system out another street, of course the engineer should be called in consultation to furnish the exact cost, but the point I wish to bring out is that the superintendent of your contracting department should feel that he is competent to consult with the engineer on this subject, and is able to take up what I might call semi-technical subjects in an intelligent way with the customers of the company.

MR. GILCHRIST: I can not indorse too highly the points that Mr. Ferguson has brought out in the paper just read. I believe, as Mr. Sherck has said, too often the men who are at the head of the business, the men who come to these conventions, know but little of the detail of the handling of their customers. I believe they realize the importance of these things, but can not give the time that they should give them. I think it has occurred to all of us, in our contact with men of great diplomacy, great attainments, and acknowledged ability, how much they are affected sometimes by small matters, how much they will worry over details. Some little thing in a business negotiation, which to another man or to a man less astute seems to be of trifling importance, they will consider of material moment. They appreciate how much the matter of like and dislike and the personal peculiarities of the man with whom they are doing business affect the trade they wish to make or the success they may hope to attain.

We have an institution in our midst which has a national reputation and of which as Chicagoans we are proud—and of which I think you as Americans are proud. I refer to one of our great Chicago institutions—the dry-goods house of Marshall Field and Company. Such an immense concern does a great business over the telephone. For a great many years the Chicago Telephone Company printed on the back of its telephone directory a sentence that originated in that house and that appeared on a card pasted above every telephone, calling the attention of the employees to the great desirability when using the telephone of being particularly courteous and particularly careful in all communications with the public to make every effort to accommodate them. I believe it is undoubtedly to that policy that the success of the house is due, and I believe we can not do too much in cultivating tactful relations with our customers by the strictest attention to the small details of the business.

Some of us feel a little acutely at times the way in which a superior will criticize when some breach of courtesy or lack of attention comes to his knowledge; but I believe it is not only the duty of that officer, but it is a thing that should be appreciated by the subordinate, to have proper correction applied whenever anything of that kind comes to the attention of his superior. The subordinate should appreciate it as a part of his business discipline, because he should realize that the superior can not know all the details of the business and must judge by these straws; and if one such occurrence comes to his attention, it is fair for him to presume that there are more, and it is not only his duty to the employee but his duty to the public to see that a sufficient example is made of the case.

MR. ARTHUR WILLIAMS: I should like to add a word of appreciation of the paper presented by Mr. Ferguson. It has been gratifying, indeed, to see that in associations of electrical men all over the country more attention is given to this question of "commercial engineering." I think this is the term that has been adopted by the General Electric Company and one or two of the other large manufacturing companies. It occurred to me during the discussion this morning when reference was made to the electrical, mechanical and hydraulic engineer, that we should possibly make room for the commercial engineer. Efficiency in selling depends on many things ; among them, tact and a full knowledge of the business. I think a commercial engineer should know as much in general of the undertaking he represents as is known in a general way, though not specifically, by other engineers connected with the undertaking.

I am reminded of an incident that occurred some time ago when a large contract was about to be placed for electrical work. The representative of the company having the best chance of getting the contract appeared one morning with soiled linen and clothing far from neat and clean. His entire appearance and manner were so offensive that immediately upon being seen by the principal in the case and stating the object of the call he was informed that the contract had been given to another company. It had not been, and the concern represented by this particular man, standing the best chance of getting the contract, lost it simply because of his appearance and the way in which he presented his mission.

Mr. S. C. Rogers (Youngstown, O.) : I want to speak on a branch of the subject that does not seem to have been touched upon by Mr. Ferguson, and that is the collection of accounts. This comes under the direct charge of the auditing department, which I represent ; the commercial engineering department, as Mr. Williams expressed it. Nine-tenths of all the complaints of customers come to the auditing department, through the medium of its collectors, cashier, or some one of its employees. It is our custom to treat such complaints courteously, and we refer them to the superintendents of the different departments for investigation. The point to which I wish to call your attention, which I think will be of value, is emphasizing the necessity of investigating such claims promptly and reporting back to the auditing department so that the collection of the account can be proceeded with. It is too often the case that the superintendents, not being responsible for the collection of the account, do not give prompt attention to the investigation and adjustment of these claims. This is a point that may well be considered by those present who are central-station managers and general superintendents.

Mr. Anthony : In regard to the same subject, I think when the customer makes his complaint, the moment the letter is received the complaint should be answered then and there, giving the customer the information that the matter will be investigated *instanter* and the result of the investigation be promptly forthcoming. You then put the customer in a proper mood to receive, perhaps, some unpleasant information later on; but he is immediately apprised of the fact that his complaint is receiving attention and you gain nine-tenths of the situation by the prompt acknowledgment of his letter in a courteous way.

MR. C. L. WAKEFIELD (Dallas, Tex.): I think the contract department often makes the mistake of having too many words in the contract. The customer, as a rule, believes that he must sign the contract or he will not get the current, and in many cases that is true. It is so long that he does not read it and so long that the contract agent does not read it *to* him when it is signed; the fact that you show him the contract when a complaint arises does not make him feel any better. I think much trouble could be avoided by making the contract as simple as possible, so long as the price and term of contract are stated. The less you say, the less you will have to take back.

MR. BRINE: In regard to complaints from customers, I should like some of the members to state if in case a customer makes a complaint about a bill being too high and the meter is found to be fast, the customer is informed that the meter is fast or if the error is explained in some other way; that is, error in reading, or something of that kind.

MR. E. F. PHILLIPS (Detroit, Mich.): I have found in my relations with the public that the old-fashioned motto "Honesty is the best policy" holds good. It is our practice to tell the customer the truth at all times, regardless of the fact whether you lose the customer or retain him. I have in mind an instance in connection with one of the most prominent citizens of Detroit, at the time we had excessive competition, who spent the summer at his summer residence and returned to town in October. He received a bill the first of November that he considered excessive. He reported the fact to the management, a thorough investigation was made, and his meter was found to be two per cent slow. This customer was valuable—one who by our making a slight misrepresentation could have been retained. He was accessible to the lines of the opposition company. What was the method of procedure? He was told that his meter was two per cent slow, but that the company valued his business to such an extent that it was willing to receipt the bill, but under no condition whatever could it acknowledge that the meter was fast when it was really slow. We lost the customer. In handling the contract department, which is under my special direction, I have found it good business policy in all cases never to tell a customer anything but what you can back up; never tell a customer anything but what is a fact.

MR. BRINE: I should like to hear from some other members as to what they do with reference to changing meters for dissatisfied patrons.

MR. C. M. LEWIS (Bellevue, O.): In answer to that question, we have found that the following method would frequently settle the difficulty: Knowing our lines and the voltage of our lamps, request the patron to place on, say, five 16-cp lamps for a certain number of hours. Have him multiply the watts per lamp by the number of lamps and hours and compare with current consumed, as registered by the meter. We teach all our customers to read their meters. While this is not an accurate test, yet it satisfies the customer. We then suggest the use of smaller-candle-power lamps where we believe they would answer, and thus reduce the bill to the customer's satisfaction. A safe wattage margin should be given. We have found this method very helpful.

THE PRESIDENT: We will now pass to the next paper, which is entitled "Relations with Employees—Benevolences, Insurance, Pensions." In these trying times, when we have such great differences between capital and labor, the question of the proper attitude of employers toward benevolent, insurance and educational associations among employees is very important. At least, we considered it very important, and asked Mr. Arthur Williams, of the New York Edison company, early in the year to make a special study of the subject, as it was one in which he was considerably interested. He will now present to us the results of his investigation.

Mr. Williams read the following paper:

RELATIONS WITH EMPLOYEES — BENEVOLENCES, INSURANCE, PENSIONS

Faithful and continuous service has a quality of future value which can not be immediately defined, and for which full compensation can not always be given, in the usual acceptation of the term. The good-will of an establishment offers an illustration of this suggestion. Good-will is frequently a large percentage of the total assets; it is obtained only through considerate and faithful service; it can not be secured where nothing more than perfunctory service is rendered.

Larger recognition is now given to this element of futurity than at any time in the past. This is evidenced by the increased extent to which employers are interesting themselves in the permanent welfare of their employees. Some aim to make their manufacturing plants attractive by comfortable surroundings, good sanitary arrangements, as much light and as little noise and vibration as possible, with recreation and assembly rooms, libraries and well-appointed dining-rooms. Oftentimes the dining-rooms are maintained without profit or with some loss. Healthy, cheerful, well-fed employees work better and faster, and in them the elements are absent that make for discontent and trouble. Some employers assist in building homes; some pay for life insurance, an excellent form of saving; some encourage part ownership — as indicated by the recent action of the United States

Steel Corporation; some, like the Pennsylvania and Baltimore and Ohio railroads, encourage the organization and assist in the management of relief and benefit associations; some, like the Pennsylvania Railroad, go a step further and, after a stated term of continuous service, provide pensions for life. There are many forms, each possessing much merit, and all contributing to the general good, and insuring more friendly relations between employers and employed.

At this point allow me to quote from the installation address of Andrew Carnegie, as president of the Iron and Steel Institute of London, than whom no one is better acquainted with the conditions of labor in our country. Mr. Carnegie states:

"The great secret of success in business of all kinds, and especially in manufacturing, where a small saving in each process means a fortune, is a liberal division of profits among the men who help to make them, and the wider the distribution the better. There lie latent unsuspected powers in willing men around us which only need appreciation and development to produce surprising results. Money rewards alone will not, however, insure these, for to the most sensitive and ambitious natures there must be the note of sympathy, appreciation, friendship. Genius is sensitive in all its forms, and it is unusual, not ordinary, ability that tells even in practical affairs. You must capture and keep the heart of the original and supremely able man before his brain can do its best. Indeed, this law has no limits. Even the mere laborer becomes more efficient as regard for his employer grows. Hand service or head service, it is heart service that counts."

It is for this heart service, of which Mr. Carnegie speaks, that these special methods for cementing the relations between employers and employees are devised. It is not a reflection that there is underlying all some form of additional compensation for which employees will strive, and the holding out in the distance of something that the employer is willing to offer for service more faithful, more interested, and of greater continuity. To accomplish these results it would seem desirable to provide for all in sickness and old age, irrespective of the compensation they receive or of their relative position, and the only system that seems fairly to do so is one that is based upon percentages —a percentage both of the normal remuneration received and of the duration of service.

Of the methods examined, that seems to be the best under which the employees provide their own relief and benefit funds and the employer the required pensions. It is proper to expect every one to save something to meet the contingencies of sickness, and to carry some measure of life insurance, but the employer, as a rule, can fairly be asked to provide for those who have given in his service the best and greater part of their lives. By contributing to a general fund approximately three per cent of his income, an employee can insure himself in illness to the extent of half his income for a considerable period of the year, and in addition he can carry approximately $500 of life insurance. And, usually, it will be found that employees who have served continuously from 25 to 35 years can be pensioned to the extent of a quarter or a third of their salary at a net cost of less than one per cent of the usual pay-roll. Insurance of $300 or $500 may not seem large, unless contrasted with the usual practice of, and I might add, the usual receipts from, "passing the hat" on the death or illness of a fellow worker.

Existing systems designed for the relief and benefit of the employees of some of our American corporations may be of interest to the association:

THE METROPOLITAN STREET RAILWAY COMPANY, OF NEW YORK

The employees of the Metropolitan Street Railway Company pay into their own organization 50 cents monthly, and receive in the event of sickness $1.00 daily for not more than 90 days in any year, and in the event of death the heirs are paid $300; the company has recently agreed to retire on life pensions, at the age of 70, all employees who have been 25 years or longer in its service, and to give them optional retirement at the age of 65; the pension given is 25 per cent of the average salary or wages received during the preceding 10 years, and increases at the rate of one per cent for each additional year of service until—I understand—it reaches a maximum of 35 per cent.

THE CONSOLIDATED GAS COMPANY, OF NEW YORK

The Consolidated Gas Company, of New York city, through an organization of its employees, has two plans in operation—one relating to sick, the other to death, benefits. An employee may take one or both, at his option. The sick benefits cost 30 cents monthly, and in the event of illness $6.00 weekly are paid during a maximum period of 12 weeks, after which the medical attendance is continued without charge. The death benefit requires a monthly payment of 50 cents, and in the event of death $300 are paid to the family or legal heirs. The Consolidated Gas Company has recently agreed to contribute to each system 50 cents for each dollar contributed by the employees.

THE UNITED STATES STEEL CORPORATION

Forty-five thousand shares of preferred stock at the par value of $100, now paying seven per cent, were purchased by the corporation and sold to the employees at $82.50 a share. One-sixth of the total of 168,000 employees subscribed for the stock twice over—showing the interest taken in this movement. The stock is to be paid for by installments, and a bonus is to be paid to those still holding their stock and continuing in the service of the corporation during a period of five years. Arrangements are to be made for a second stock distribution of the same order, and a bonus is promised for the second five-year period, but the amount is not stated. In addition the directors have agreed to set apart yearly one per cent of the earnings in excess of $80,000,000, and one-fifth of one per cent for each additional $10,000,000, as a fund to be awarded to the officials and men who, in the judgment of the directors, best deserve it. This sum is not to be distributed *pro rata*, but as a reward of individual merit.

THE ILLINOIS CENTRAL RAILROAD COMPANY

A somewhat similar method of interesting the employees of the Illinois Central Railroad was adopted some years ago. A short quotation from a circular letter of Mr. Stuyvesant Fish, president of the railroad company, will explain the method adopted:

"On the first day of each month the company will quote to employees, through the heads of their departments, a price at which their applications will be accepted for the purchase of Illinois Central shares during that month. An employee is offered the privilege of subscribing for one share at a time, payable by installments in sums of $5.00 or any multiple of $5.00, on completion of which the company will deliver to him a certificate of the share registered in his name on the books of the company. He can then, if he wishes, begin the purchase of another share on the installment plan. The certificate of stock is transferable on the company's books, and entitles the owner to such dividends as may be declared by the board of directors and to a vote in their election.

"Any officer or employee making payments on this plan will be entitled to receive interest on his deposits, at the rate of four per cent per annum, during the time he is paying for his share of stock, provided he does not allow 12 consecutive months to elapse without making any payment, at the expiration of which period interest will cease to accrue, and the sum to his credit will be returned to him on his application therefor."

On June 30, 1900, 3,090 shares of the company's stock had been purchased and paid for under this plan; the average cost to the purchaser being $98.13, and the market price at the time being $116 per share.

OTHER METHODS

I have been told that the Krupps, at Essen, Germany, in addition to very liberal provision for the comfort of their employees—one feature being a club-house splendidly equipped—guarantee that after reaching a certain age, with good record of service, they shall be retired with an annual pension and a small house in which to live. The pension and the use of the house are continued to the widow in the event of the decease of her husband. A firm in New York city, in addition to paying a high rental premium to secure abundant natural light and the use of modern apparatus of every nature, insures its principal employees at its own expense, and assists them in the purchase of homes. This is done in the belief that a man's expenses keep pace with his income, and, therefore, by giving income advances in the form of annual payments on insurance or property, a permanent saving to that extent is effected, and the interests of the employees are more surely identified with their work. For example, this firm paid $500 last year on a house of one of its foremen, and expects to make a like payment this year and hereafter as long as the present relationship continues.

PENSION AND BENEFIT ORGANIZATIONS AND SOME METHODS EMPLOYED IN DEALING WITH LABOR ON AMERICAN RAILROADS

It is probable that this subject has received the closest attention from the large railroad organizations of our country.

Samuel M'Cune Lindsay, Ph D., in Bulletin No. 37 of the Department of Labor, makes the following statement regarding railway employees:

"Probably railway labor, as an occupation, affects the interests of more persons in the United States than any other single branch of employment except agriculture. It is one of the most hazardous occupations, and yet one on which the prosperity of the country becomes increasingly dependent. It has led almost all other classes of labor in meeting the problems peculiar to the wage-earner when he becomes conscious of the class feeling. Organized labor has fought its chief battles, won its greatest victories, had its severest defeats, and learned its best lessons, within the scope of railroad employment. The problems of old age, the question of the 'dead line' in occupations, or age where diminishing efficiency sets in, and the need of provision for the uncertainties of life, have nowhere presented themselves with greater clearness and been met with greater determination than in the relations of employer and employee in the realm of railway labor."

While recognizing that individually our own is of a more limited field, there are many parallels between it and railway work, and many lessons in regard to labor matters can, I think, be learned in considering the relations between the railroads and their employees during the past several years.

NUMBER OF RAILROAD EMPLOYEES

The Thirteenth Annual Report of the Interstate Commerce Commission states that on June 30, 1900, there were 1,017,653 employees of all classes engaged in railway transportation; there was an average of 529 employees per 100 miles of line, and an increase of 88,729 employees, or 34 employees per 100 miles of line, as compared with the previous year. But with this increase in the number of employees there was also an increase in the amount of work performed by each. For example, the figures for 1893 show that in the freight service 107,129 ton-miles of traffic were handled for each employee, while in 1900 139,143 ton-miles were handled.

The railways require that all employees except unskilled day laborers shall have as a general basis a good common-school education. They then require that employees work their way up through the lower grades of the service, familiarizing themselves by actual experience with the needs of the better paid positions for which they may have special aptitude and natural ability. College graduates frequently begin in train service as firemen on freight engines.

The better the general training and education a man has before entering railway employment, the more rapid is apt to be his advancement. Age qualifications are such that it is now difficult for any one over 35 years of age to enter railway service without previous railway experience—many roads, as, for example, the Pennsylvania, do not employ any new men over 35 years of age.

DISCIPLINE

Discipline is a question that has received a great deal of recent attention, and as one result the causes for instant dismissal have been largely reduced in number. Many of the roads maintain boards of inquiry, to which appeals may be made by even those of the lowest ranks, though there are certain causes for instant dismissal which, proven, have no appeal, such as flagrant violation of rules, intoxication, insubordination, dishonesty and gross carelessness or negligence.

Promotion, if not entirely, largely depends upon previous record and the results of various examinations. So far as practicable, all of sentiment or of politics is eliminated. Discipline is administered usually in three ways: Instant dismissal; suspension from work and pay for a period of 10 to 60 days; reprimand and record of deficiency. The third form, little known some years ago, has now almost superseded the other two.

THE BROWN SYSTEM OF DISCIPLINE

Discipline by reprimand and record is generally known as "The Brown System of Discipline," because it was first worked out by Mr. George R. Brown, general superintendent of the Fall Brook Railway, of New York. This method has been referred to at length by Mr. A. D. Stickney, president of the Chicago and Great Western Railway, in a paper entitled

"A Study of the Methods of Hiring, Disciplining and Discharging Railway Employees," and some of his remarks may be of interest to the association. Mr. Stickney defends the Brown system, not from sentimental reasons nor chiefly as a promoter of the interests of labor, but in the interests of the companies. He states that the primary reason for discipline should be the improvement of the service, not the punishment or reformation of the man, nor primarily object lessons to other men; that the improper use of the discharge method has been "the vital spot of all brotherhood organizations."

Suspension from duty and pay by the immediate employing officer is also opposed. Mr. Stickney states that suspension without investigation and without any measure of the degree of culpability is almost always unfair, and is usually administered in a spirit of anger; the person administering the punishment is usually the sole judge of how to make the punishment fit the crime, and simply because of the momentary condition of the administrator, the highest punishment is often inflicted for a petty disobedience, which resulted in no serious consequences.

The question of who shall administer discipline is of no less importance than the form the discipline is to take. The Brown system discards the idea of punishment and penalty, and maintains that it is no part of the directing forces of the employer to punish the employees; it maintains that those forces should be utilized solely for the purpose of planning and intelligently directing the work. Upon this point President Stickney makes the following observations:

"This school holds that there is an indefinable something in the lawful authority which the foreman possesses, combined with superior intelligence, superior dignity of character, and superior self-possession, which every foreman should possess, which commands obedience to intelligent directions."

The basic idea of the Brown system is the record book, in which a page is devoted to the personal record of every employee. The book itself is never shown. Any employee can get a copy of his personal record at any time. Of this record Mr. Brown makes the following observations:

"In it I write down a brief statement of every irregularity for which a man is responsible. This record takes the place of the 'lay-off,' and is dreaded fully as much. The man goes to work at once, no one but himself suffers, and he only in reputation at headquarters.

"When a man commences to make a record in the book we call him in and talk to him. He is reminded that if this gets too long we shall have to consider him a failure for our service; show him his weakness, and give him another chance."

A second important feature of the Brown system is a bulletin which, with the record book, makes up the substance of the plan. The bulletin is a publicly posted record of every irregularity on the road; it gives no names, simply describes the accident or irregularity and then comments upon it from the company's point of view, suggesting how the accident might have been avoided or how injurious it was to the interests of the company.

Some of the objects of his method are stated by Mr. Brown to be as follows:

"*First*—To secure a higher state of efficiency Strict discipline is essential to successful operation.

"*Second*—To avoid loss of time and wages of employees, which results in possible suffering to those dependent upon their earnings. There is also the chance of demoralization by enforced idleness.

"*Third*—To avoid unnecessary severity in the dismissal of an employee or in requiring him to serve a suspension for a single offense that does not reflect upon his reputation, conduct, capacity or future usefulness.

"*Fourth*—To remove the false, but too common, impression in the minds of employees that the amount lost to them in wages is a payment for the loss in trouble caused the company.

"*Fifth*—To avoid frequent change in the service.

"*Sixth*—To advance the education of employees through the medium of bulletin notes, thus enabling them to avoid mistakes made by others.

"*Seventh*—To establish a feeling of security and the confidence that faithful service will be recognized, and rewarded by uninterrupted employment, and with the certainty that reward and promotion will not follow indifferent service."

AN INTERESTING EXAMPLE

An interesting example is given following the adoption of the Brown system on the Long Island Railroad. On a certain section, 10 miles long, 116 flagmen or gatemen, each earning about $40 monthly, are in service. The former practice was to suspend these men for delinquencies for periods ranging from three to fifteen days, and an average of eight men was required daily to replace those suspended. After the adoption of the discipline system without suspension, over a considerable period, there was but one failure to appear on time, and in this instance the employee overslept. With this method it became un necessary to send a gang over the road each morning to replace the delinquents; the men seemed willing to accept occasional suspension, but not the risk of losing permanent employment.

On some roads the Brown system has been extended so as to include demerits to delinquents on the one hand, and on the other merits for acts of heroism and for even minor evidences of fidelity and intelligent interest to the work. An extension of this plan has also been tried, allowing a certain period of clean record to cancel a certain period of bad record. For example, on one road suspension of 15 days or less would be considered canceled by a perfect record of one year; suspension for more than 15 but not exceeding 30 days, would be canceled by a perfect record of two years; of 30 days but not exceeding 60 days, by a clean record for three years. In some instances complimentary bulletins are issued every 12 months, stating the names of employees who have made a perfect record for the year.

THE PENNSYLVANIA RAILROAD COMPANY

Of our American corporations, the most marked progress in securing a method of caring for the interests of employees has been made by the Pennsylvania Railroad Company, through its "voluntary relief department" and "pension department"—separate organizations. Since the organization of these departments there has been no serious labor trouble on this railroad, though previously there were a number of disturbances—wide in extent and serious in nature.

The relief department was organized in 1886, as the result of the evident need of more effective means for meeting distress incidental to sickness and death than that of soliciting voluntary subscriptions from friends and associates, and is administered through a superintendent appointed by the board of directors. There is also an advisory committee composed of 12 members, of whom six represent the company, and six are chosen by the relief department members from among themselves. To this committee is charged the responsibility for seeing that the department is conducted in accordance with the regulations, which are in printed form, and of providing for the care and investment of the relief funds. The general manager of the company, by virtue of his office, is chairman of the committee. The superintendent of the department is the secretary of the committee, and the railroad company acts as the custodian of the relief funds.

RELIEF-FUND REVENUES AND PAYMENTS

The revenues of these funds are derived from three sources: Dues from members; interest paid by the company on current balances; contributions by the company to make up deficiencies. The membership is entirely voluntary. During the year 1902, the average monthly membership was 63,916; at the close, the aggregate membership was 70,307; the relief-fund account was credited with $1,297,187.61; the benefits paid amounted to $1,034,820.98; the balance at the end of the year was $262,366.63.

There are three additional funds or accounts in this department: the "relief-fund liability account," which at the close of the year had a credit of $120,319.89, the "relief-fund surplus account" having a balance of $751,256.25, and a "superannuation fund," which in the year of 1902 amounted to $40,276.57, made up of a small balance and the interest on the relief-fund surplus, all of which, with the exception of $10.20, was paid to superannuated employees, during the year.

During the 17 years' operation of the department there has been paid to the employees in sick, accident and death benefits the sum of $9,884,909.19; in addition, the company has paid $2,264,659.63, of which $1,613,457.72 were expended for operating expenses—a total of $12,149,568.82. The company maintains the department at its own expense, paying the salaries of those who direct it, the medical expenses, furnishes the necessary offices, stationery, etc. It is undoubtedly due to liberal policy and thorough organization that the success of the department has been so marked and the results so beneficial to the working forces of the Pennsylvania Railroad Company.

An analysis of the benefits paid during the year shows the following:

Deaths	Number	Insurance Paid
By accident	313	$158,585.17
From natural causes	546	283,956.81
Total	859	$442,541.98
Disablements	Number	Benefits Paid
By accident	13,877	$217,890.05
By sickness	27,975	374.388 95
Total	51,852	$592,279.00
	Number	Amount
Total of both death and disablement payments	52,711	$1,034,820.98

In disablements the average duration is, accidents 19.6 days, sickness 18.1 days. It will be noted that of 859 deaths during the year, 313, or about 36 per cent, resulted from accident; of 51,852 disablements, 13,877, or about 26 per cent, were from accident. In the electric-light industry, the accident claims, while not entirely eliminated, would be largely reduced. The fact that in both death and disablement benefits much the larger percentages result from natural causes, shows that, while railroading may be termed an extra-hazardous occupation, there is, with all classes of employees, every reason to provide for illness and other uncontrollable circumstances.

CONTRIBUTIONS TO RELIEF FUNDS

Contributions to the relief funds are made in accordance with a graduated scale, proportioned to the wages the members earn. There are five classes, the details of each being shown in the following tabulation, taken from the Regulations of the Voluntary Relief Department, as amended to January 1, 1900. The tabulation also shows the benefits received in the event of disablement or of death.

	1st Class	2d Class	3d Class	4th Class	5th Class
Monthly pay	Any Rate	$35 or more	$55 or more	$75 or more	$95 or more
Contribution per month—					
Class	$0.75	$1.50	$2.25	$3.00	$3.75
Additional Death Benefit, equal to Death Benefits of class—					
Taken at not over 45 years of age	.30	.60	.90	1.20	1.50
Taken at over 45 years and not over 60 years of age	.45	.90	1.35	1.80	2 25
Taken at over 60 years of age	.60	1.20	1.80	2.40	3.00
Disablement Benefits per day, including Sundays and holidays:					
Accident—					
First 52 weeks	.50	1.00	1.50	2.00	2 50
After 52 weeks	.25	.50	.75	1.00	1.25
Sickness—					
After first three days, and not longer than 52 weeks	.40	.80	1.20	1.60	2.00
After 52 weeks	.20	.40	60	.80	1.00
Death Benefits—					
For Class	250.00	500.00	750.00	1000.00	1250.00
Additional that may be taken	250.00	500.00	750.00	1000 00	1250.00

The minimum contribution in each class averages about three and a half or four per cent of the wages of the employees—the percentage is highest where the employee receives the minimum wages of the class.

But there comes a time when the employees cease to earn wages, and, therefore, are unable to pay monthly dues to the organization. It is then that ordinarily they must rely upon their savings, the assistance of relatives or of friends, or upon charity. The percentage of those who save enough to sustain them in old age is very small, probably largely because of thoughtless expenditure and failure to realize the ultimate value of accumulated savings, even though the individual savings be small. The Pennsylvania Railroad, not alone of the railroads or other corporations in this country, but referred to at greater length because of the extent to which the matter has been investigated, then took up the question of pensioning all of its aged employees, and in 1890 put a system into effect, of which the following are some of the features—quoting from the Pennsylvania Railroad Company's general notice of December 18, 1899, and signed by the president, Mr. A. J. Cassatt:

"*First*—All officers and employees of the company who are required by the organization to give their entire time to the service of the company, who shall have attained the age of 70 years, or who, being between the ages of 65 and 69 years, inclusive, shall have been 30 or more years in the service of the company, and shall then be physically disqualified, shall be relieved and placed on the pension roll.

"*Second*—Subject to ratable reduction, so that the entire annual expenditure for pension allowances shall not at any time exceed the aggregate sum of $300,000, pensions shall be allowed upon the following basis:

"*Third*—For each year of service one per centum of the average regular monthly pay for the 10 years preceding retirement. Thus, by way of illustration: If an employee has been in the service of the company for 40 years and has received on an average for the last 10 years $40 per month in regular wages, his pension allowance would be 40 per cent of $40, or $16 per month.

"*Fourth*—Pension allowances shall be paid monthly and shall terminate on the death of the beneficiary.

"*Fifth*—No pension allowance shall be paid to any officer or employee for a period during which he may be receiving accident or sick benefits from the relief department.

"*Sixth*—The acceptance of a pension allowance shall not debar the beneficiary from engaging in other business; but such person can not reenter the service.

"*Seventh*—The pension department shall, under the supervision of the president, be in charge of a board of officers, consisting, until otherwise ordered, of the vice-presidents, the general manager, and the assistant comptroller of the Pennsylvania Railroad Company. The board of officers shall be appointed annually by the boards of directors of the several companies, and shall, subject to the approval of the said boards, make and enforce regulations for the government of the department.

"*Eighth*—No action, which shall now or hereafter be taken in connection with the origin or furtherance of a pension department or plan, shall be held or construed to give any officer, agent, or employee a right to be retained in the service or become entitled to pension allowances, but, on the contrary, each company may discharge any officer, agent, or employee at any time, when in its judgment the interests of the company so require, without liability for pension or for other allowances, save only salary or wages then earned and unpaid.

"No person shall be taken into the service of the company who is over 35 years of age, except that, with the approval of the board of directors—

"*First*—Former employees may be reemployed within a period of three years from the time of their leaving the service.

"*Second*—Persons may, irrespective of age limit, be employed where the service for which they are needed requires professional or other special qualifications; but

"*Third*—Persons may be temporarily taken into the service, irrespective of age limit, for a period not exceeding six months, subject to extension, when necessary, to complete the work for which engaged."

The assistant comptroller of the Pennsylvania Railroad Company, Mr. Riebenack, stated in an address before the Economic Club, of Boston, at the annual dinner on February 10, 1903, that a special committee, appointed to consider the pension question, examined into and reported upon the various pension systems in operation on more than 70 of the leading railroads of America, Europe, Asia, Africa and Australia. Even the enormous amount of data thus collected was not sufficient for the formulation of the pension plans of the directors, the scope not being sufficient, and, therefore, in adopting the present system, progress was made along lines original and more extensive than had before been undertaken by any corporation.

PENSION EXPENDITURES AND COST TO THE COMPANY

There were paid to retired employees during the three years of operation, beginning January 1, 1900, pension allowances aggregating $864,713.27. In the same years—1900, 1901 and 1902—1,851 employees were retired, of whom, in that period, 381 died. Three hundred and fifty-nine were between 65 and 70 years of age, physically incapacitated, and of this number, 261 were relieved by their own request, with the approval of the employing officers. The average age of the pensioners on the roll at the end of 1902 was 73 years, and the oldest pensioner was 91 years of age. At the end of 1902 the percentage of pensioners to active employees was 1.47, the pensions paid then aggregating $300,000, approximately $3.24 per annum for each employee of the railroad company, and about .57 of one per cent of the annual pay-roll. When it is pointed out that this pension expense aggregates less than one cent per day for each employee, it would seem (*a*) that were employees to act jointly, they could themselves provide for old age at an expense not exceeding one cent a day; or (*b*) that any corporation by the same method could reach the same result—and that, for the influence upon employees, the corporation could well afford, entirely at its own expense, to take such a course. Contrast with these figures the cost of a single labor disturbance, or the value, relatively, of faster and better work, of better and closer attention to an employer's property and interests; of stimulating devoted and enthusiastic effort on the part of each employee. The cost of securing this fades into insignificance.

It will be noticed that the Pennsylvania Railroad Company has limited its liability to a stated annual amount; that it simply agrees to pay the defined percentages for pensions, provided that the sum allowed is sufficient for that purpose. If it is not, either a larger amount would have to be allowed by the directors—which would be optional—or some decrease in the pension rate would follow.

INVESTIGATIONS BY THE NEW YORK EDISON COMPANY

The New York Edison company has given recent consideration to this subject, though the plans thus far outlined are not as yet beyond the stages of earliest consideration. Briefly stated, they are as follows:

"*First*—The organization of a relief association, in which it is proposed that each member shall pay three per cent, and in the event of accident or illness, receive half of his wages or salary; that in the event of death his heirs shall be paid $350. The constitution of the association would be so drawn that the obligation to maintain these payments would continue only as long as they are justified by the income—it being the intent that while the company should meet the administration and medical expenses, the disability and insurance expenditures shall be entirely contributed by the membership.

"*Second*—That the company shall pay to all employees serving it *continuously* for a period of 25 years, for each year of active service, an annual pension for life of one per cent of the average salary or wages received during the preceding ten years. As with the Pennsylvania Railroad Company, the intent is to place a limit upon the total expenditure of approximately $3.80 annually for each employee on the payroll. Beyond this the company would have no liability, so that, unless further action were taken, it would be necessary to scale down the percentage of pension payments were this allowance not sufficient for that purpose."

The plan suggests that no pressure whatsoever shall be brought upon the employees to join the association other than the fact that it will furnish an inexpensive way of providing for illness and for some insurance.

The constitution and by-laws are to be carefully drawn with legal advice; the fiscal officers of the department would be the fiscal officers of the company holding corresponding relations; the chairman of the board of directors, by virtue of his office, the general manager or the associate general manager of the company. But otherwise this board, under constitutional provisions, would have control of the department and would be composed of equal representation on the part of the company and of the employees.

The company felt that several points involved, particularly legal, should be carefully considered by its attorneys, and the following opinion may be of interest to the association, and of value to any companies intending to take action on this subject:

EXTRACTS FROM AN OPINION RENDERED BY THE ATTORNEYS OF THE NEW YORK EDISON COMPANY

"We have carefully looked over the papers and pamphlets which we have in our possession bearing upon a similar (pension and relief) department which has been conducted by the Pennsylvania Railroad Company, and have also considered the decisions of various courts upon questions which have arisen under this or similar schemes.

"As we have stated, the pension fund would be a direct charge upon the company, and as it is gratuitous, the company could not be attacked legally by reason thereof, as there would be no interest in that fund to which any of the employees would contribute. That branch of the proposition, therefore, would probably cause no trouble to the company.

"The relief and insurance branch, however, seemed at first to us to have some objections, but, after considering the system which has been adopted by the labor efficiency—added to which would be perhaps greater individual effort in work and devotion to the employers' interests.

In closing permit me to acknowledge my indebtedness to the bulletins of the Department of Labor issued from the Government Printing Office at Washington; to the work of Samuel M'Cune Lindsay, Ph.D.; to Mr. M. Riebenack, assistant comptroller of the Pennsylvania Railroad Company; to Mr. Spencer Mead, superintendent of, and Mr. C. S. Wells, connected with, the relief department, and to various reports of the Pennsylvania Railroad Company; to Messrs. Beardsley and Hemmens, attorneys of the New York Edison company; and to the reports of several corporations also maintaining benefit associations.

MR. WIRT: I would ask Mr. Williams if, in the investigation of this subject, he found any opposition on the part of the employees to these societies? A friend of mine paid some attention to this subject, and in several cases the employees made the statement that they would prefer to have the additional salary—prefer to make their own savings to provide for their old age. In Germany the employers are compelled by law to make provision of this kind. I should like to know if Mr. Williams looked into that aspect of the matter—the possible objection of the employees?

MR. WILLIAMS: I have not found that there is any objection on the part of the men to the additional payments made to these societies, because they are entirely voluntary. and usually the men get a great deal more than they take. I know of no company that asks any employee to join a benefit organization unless it is his desire to do so. He may join if he desires it, but it is optional with him. Most of the organizations are composed entirely of the employees, who in some cases are assisted by the executive management of the corporations. Pensions, however, are administered by the employers and are given to each employee, whether he belongs to the benefit organization or not. There is no necessary relation between the sick and insurance benefit organization and the pension system. I have heard about the German system, but could not get enough information to include reference to it in this report. It places some obligations on manufacturers engaged in hazardous undertakings to insure the lives of their employees, and the employers are under some form of obligation to provide a pension fund for old age.

THE PRESIDENT: I will read by title a paper prepared by Mr. W. D'A. Ryan, entitled "Light and Illuminating Engineering." This paper is not on the programme, but Mr. Ryan was kind enough to prepare it for the meeting; but owing to the large number of papers we have and the time it would take to present the paper in full, it will not be possible for us to have it read.

(The following is the text ot Mr. Ryan's paper. It was accompanied by several illustrations, some of which were in color, elucidating the subject. It has not, however, been found feasible to reproduce these illustrations.)

LIGHT AND ILLUMINATING ENGINEERING

CONCENTRIC AND ADJUSTABLE DIFFUSERS

The superior quality, volume and economy of the electric-arc light are so well recognized that it is rapidly supplanting all other artificial lights for high-class mercantile illumination. The open arc, while giving an especially white light of high candle-power, concentrates the most powerful rays in a comparatively small circle beneath the lamp. The circle incloses a dark zone directly under the lamp, and beyond the ring of concentrated light the illumination falls off rapidly, producing an unevenness incompatible with good lighting, particularly when the surroundings are dark and not of a diffusive character. Not only is it impossible to show material satisfactorily where the light is weak, but merchandise displayed in the strong circle of light is so brilliantly illuminated that in the case of colored fabric the eye fatigues and the complementary color introduces itself, which robs the original color of its purity. This in many cases causes the customer to become undecided, and a lost sale results. If there were any way of estimating lost business due to this cause the figures would undoubtedly be surprising.

In many stores fatigue and subjective color effects produced by the open arc are partly corrected by the use of dense globes. There still remain, however, equally serious inherent defects, namely, the distortion of the light distribution due to the wandering of the arc and to the great change in the total volume of light at different increments of time between the so-called picking-up and feeding points.

When the inclosed lamp was placed on the market, it was soon recognized as having superior advantages of distribution, steadiness and maintenance economy over its predecessors, and so rapidly is it replacing the open-arc lamps that the latter will in a very short time be regarded as entirely obsolete

In order to further improve the distribution of light with the inclosed arc and adapt it to particularly severe requirements, after a careful study of this important problem the concentric light diffuser has been introduced. This apparatus, while of an exceptionally simple character, not only cuts down sharp contrasts and diffuses the light equally in all directions, but the effect of the wandering of the arc has been reduced in a considerable degree, so that the light at any point is to a great extent independent of the position of the arc with respect to the carbon ends.

The apparatus consists of a suitably designed metal diffuser attached to the lamp casing in the same manner as an ordinary reflector or shade. In place of the outer globe a screening shade is used, which performs the double function of subduing the light directly under the lamp, and reflecting a portion of it to the diffuser. The light from the diffuser is white, even, well distributed, easy on the eyes and particularly adapted to the matching of colors, which is of the utmost importance in a very large percentage of all classes of mercantile lighting. Furthermore, the diffuser makes the illuminating power of the lamp independent of the nature or color of the ceiling; that is to say, it is immaterial whether the ceiling is light or dark. With the diffuser the light will be about equally effective under all overhead conditions, as there will be practically no light lost by absorption in the ceiling itself.

MILL LIGHTING

Semi-concealed arc lighting is especially recommended for use in cotton, silk or other mills where arc lighting is generally difficult owing to shadows cast by high looms and other light-intercepting objects. For printing, calendering, folding and other machines requiring concentrated light, the adjustable diffuser has been especially designed. It can also be used for the lighting of mills with high-studded ceilings or saw-tooth roofs. The diffuser is so constructed that the light can be adjusted so as to change the distribution without moving the lamp. This makes it possible to throw more light on a given loom that may require a stronger illumination, and this can be satisfactorily accomplished without disturbing the operators on other looms, which would naturally follow a change in the location of the lamp itself.

The arguments advanced in favor of the concentric diffuser may generally be applied to the adjustable diffuser, except that the latter throws the light only on three sides. The lamps are usually small units and are placed back to back. It will be found, however, that in the majority of cases the concentric diffuser will be most satisfactory for general illumination, particularly if the mill to be lighted has a low-studded roof or ceiling.

ARC-LIGHTING DATA

It must be recognized that to give definite data on the amount of light or power required to illuminate a given area is most difficult. Not only does there exist a wide difference of opinion as to volume of light that should be called satisfactory for a given set of conditions, but the conditions are so variable that it is practically impossible to lay down a set rule; for instance, the amount of light required varies with the dimensions of the building, the height and color of ceiling (when the concentric diffuser is not used), color of walls, also the number of obstructions in the centre of the area illuminated as well as in the nature of the stock, that is, whether it is generally light or dark, etc. Therefore, each building illuminated practically calls for a separate piece of engineering based on the particular condition to be contended with.

Close attention to the matter of general lighting and the compilation of data have enabled us to suggest some general figures that will answer for average conditions. We have also added a maximum and a minimum to cover extremely good or particularly bad conditions of lighting. In any case, the figures will serve as a general guide.

It will not be necessary to differentiate between alternating or direct current or units of different sizes, as one set of figures will in general answer for all cases. For example, if the area illuminated has a high-studded ceiling of, say, 14 or 15 feet, it is better practice to use, say, 6-ampere lamps and take advantage of the higher efficiency of the larger units. If, on the contrary, the ceiling is low, say eight or ten feet, and there are a number of obstructions that would intercept the light from the various lamps, to get the best effect it will be necessary to use small units of, say, four amperes. The better distribution of the small units in this particular case will offset the higher efficiency of the larger units. The amount of power consumed per square foot should figure up about the same in either case. When laying out a lighting plan, if the question of a few watts more or less arises it might be well to bear in mind that a strong interior illumination is a valuable advertising feature, and in many cases it would be better policy to add the power frequently expended on the front of the building to the lighting of the interior.

COLOR

Where colored merchandise is displayed, the question of uniform and steady illumination is of somewhat secondary importance in comparison with the consideration of the color or quality of the light. In general, we are accustomed to regarding the colors of all objects in nature as being the property of the material itself, whereas in reality the color depends upon the composition of the light and the power of extinction of the various objects illuminated; that is to say, natural bodies possess the power of selective absorption, hence arises the phenomenon of color. When light enters a body and is totally absorbed, the object is black. When all the waves are equally absorbed, but not totally, the object is gray. When the various waves are obsorbed unequally or selectively, the object is colored. The sensation of white, such as produced by average daylight, is made up of all the colors coming within the range of color perception. Artificial lights differ from daylight more or less in their composition or the proportions of the different colors they contain; for instance, a light may be composed of too much red or green, while the violet waves may not be present in sufficient quantity. Certain artificial lights emit too much violet and others are rich in yellow. In such cases, where the balance is destroyed, the light is no longer white, but the excess or absence of some particular shade is clearly noticeable, not only by the color effect, but also by a lack of general brilliancy or distinctness.

A piece of so-called red material exhibited in what is known as the mercury arc light appears almost black, as this light contains very little red, and red material usually is not physically constituted so as to noticeably reflect or re-radiate any other color. We therefore have total absorption, which results in a lack of luminosity of the object upon which the light falls.

Violet or blue materials displayed in the light of the Welsbach, Nernst or incandescent lamps appear dark and somewhat murky in character as contrasted with their appearance in daylight, or arc light. Yellows in the light of the Nernst or incandescent become pronounced, and slight differences in pale yellows can hardly be distinguished from one another; nor can a very pale yellow be well distinguished from white, as the latter is capable of re-radiating almost as much yellow light as the former. The same is true of white and greens exhibited under the Welsbach or hydrocarbon lights.

The white light emitted by the inclosed-carbon arc lamp is primarily projected from the crater. To this is added a certain amount of violet light, of which the arc is mainly constituted. This abundance of violet unbalances the spectrum, and it becomes necessary to use an opal inclosing globe to screen out the excess violet and bring the light to an average daylight balance. This is also further improved by the concentric diffuser, which is coated with enamel, having a selective absorption for the short waves. We therefore have at our disposal means of filtering or purifying the arc light in a high degree so that colored goods can be displayed with practically daylight effect.

In order to bring out prominently the superiority of the electric-arc light for color matching and selection, three instruments have been designed, namely, the para-chromoscope, the lumi-chromoscope and the photo-chromoscope. With any one of these instruments a prospective customer can compare the effect of different lights on colored fabric. The lumi-chromoscope, for instance, is arranged so that four lights, say the arc, Nernst, Welsbach and incandescent, fall simultaneously on the material under examination. Each light forms a patch two and one-half inches square, with a black border separating the squares so as to reduce simultaneous contrasts and gradation. The lights are arranged at such a distance that the relative intensities of the various lamps on the material are the same, thus eliminating a difference due to tint and shade. The accompanying color charts are reproduced from colored silks in the lumi-chromoscope, and show the appearance of the material under the four lights mentioned. It is very difficult to reproduce these colored effects with great accuracy, but every precaution was taken to make the reproduction as nearly perfect as possible.

80-VOLT VERSUS 100-VOLT ARCS

We have thus far confined our attention to the nominal 104-volt alternating and 110-volt direct-current inclosed-arc lamps run at about 75 or 80 volts at the arc. An attempt has been made to increase the efficiency of the 110-volt direct-current lamp by raising the voltage at the arc to 100 or thereabouts. When the potential is thus raised from 80 to 100, the crater, which varies its dimensions only with the current, is not increased in size, and as the white light emitted from the lamp is essentially crater light, there is no appreciable gain from this source by an increase in voltage. There is, however, an increased violet light, due to the greater length of the arc. Before this is suitable for normal color display the excess violet must be filtered out by using globes of greater density than those employed for filtering the smaller amount of violet in the 80-volt arc. While the opal globe has a strong selective absorption for violet, it also quenches some light throughout the entire spectrum, and by the time the 100-volt arc is properly balanced for color the efficiency is reduced by the absorption of the glass to a point below the efficiency of the 80-volt arc corrected for color to the same extent. Furthermore, the long arc is unstable, and produces flickering quite apart from the surging due to the wandering of the arc over the square carbon tips. While the wandering is sufficiently slow to enable the eye to accommodate itself to the changing intensity without injury, the flickering of the excessively long arc is so rapid that the eye can not respond without strain, and the effect is not only disagreeable but to most eyes decidedly injurious. On the other hand, to obtain this apparent high efficiency of the 100-volt arc, expense must be added to the lamp in the form of a reactive coil, which replaces the dead resistance, and the mechanism must of necessity be more delicate and the initial cost of the apparatus correspondingly increased. Therefore the efficiency, on the basis of watts at arc over the watts at terminals $\left\{\frac{\text{watts at arc}}{\text{watts at terminals}}\right\}$ is of far less importance than the consideration of the color and actual illuminating efficiency of the light itself. To give credence to the former point and neglect the latter is liable to lead to an unwise selection of lamps.

The foregoing arguments against high-voltage inclosed-carbon arcs apply with still greater force to the 2.5 or 2.75-ampere, 140 or 160-volt arc lamps run on 220-volt circuits. The candle-power per watt of these lamps is very low and the light is excessively violet, being far beyond economical color control. Such lights have a high actinic value and may be used to advantage for photographic purposes, but for general illumination practically double the efficiency is obtained by using two 80-volt arcs in series.

WATTS PER SQUARE FOOT FOR HIGH-CLASS ARC LIGHTING

Building	Average Conditions	Variation
Machine Shops, high roofs, electrically driven machinery, no belts	* .75	* .5 to 1.
Machine Shops, low roofs, belts and other obstructions	1.	.75 to 1.25
Hardware and Shoe Store	.75	.5 to 1.
Department Stores, light material, bric-a-brac.	1.	.75 to 1.25
Department Stores, colored material	1.25	1. to 1.5
Mill Lighting, plain white goods	1.1	.9 to 1.3
Mill Lighting, colored goods, high looms	1.3	1.1 to 1.5
General Office, no incandescents	1.5	1.25 to 1.75
Drafting Rooms	1.75	1.5 to 2.

* Energy based on watts at lamp terminals.

LIGHTING DATA

Place Lighted	Clothing Store	Weave Room	Erecting Room	Machine Shop	Drafting Room	Drafting Room	Ship Shed	Cataloging Dept.	Jewelry Store
Number of square feet place lighted	4,000	11,400	281,600	42,250	6,275	5,690	69,000	4,136	4,000
Number lamps used	12	50	200	42	27	24	50	17	6
Catalogue number lamps used	3443	3475	CS. 35309	CS. 35309	3182	Special	3484-3500	3468	3468
Catalogue number casing used	3545	3573	CS 35705	CS. 35705	3516	Special	3589	3559	3559
Circuit	A. C. Mult.	D. C. Mult.	D. C. Mult.	D. C. Mult.	A. C. Series	D. C. Mult.	*D. C. Mult	D. C. Mult.	D. C. Mult.
Cycles	60	......	......	......	60	......	......	......	......
Volts line	104	110	120	120	......	120	220	110	110
Amperes	6	3.25	6.2	6.2	7.5	4	6	4.5	5
Volts at arc	72	75	80	80	72	80	80	80	80
Power factor of lamp	.69	......	......	......	.86	......	......	......	......
Watts per lamp	430	357	744	744	490	480	660	495	550
Watts per square foot (term.)	1.29	1.24	.53	.74	2.11	2.02	.478	2.03	.825
Kilowatts at terms. (whole installation)	5.16	17.8	148.8	31.25	13.22	11.52	33	8.42	3.3
Kilowatts at arc (whole installation)	4.62	12.28	99.2	20.8	12.42	7.68	24	6.12	2.4
Square foot lighted per lamp	333	288	1,408	1,006	232	237	1,380	243	667
Square foot lighted per ampere	55.6	88.6	227	162	31	59.2	230	54.1	133.5
Inclosing globe	No. 3 Opal	No. 3 Win.	No. 46 Opal	No. 46 Opal	No 3 Opal	No. 3 Opal	No. 3, No. 46	No. 3 Opal	No. 3 Opal
Height and style of ceiling	12' White Steel	Saw Toothed	Trussed	Trussed	12' White	Trussed	160' Trussed	13' 9" Maroon	16' 10" White
Reflector system used	Concentric Diffuser	Adjust. Diffuser	9" Mirror	9" Mirror	Concentric Diffuser	16 Adj. Dif 8 Con. Dif.	12" Mirror	Concentric Diffuser	Concentric Diffuser
Height of arc from floor	9' 0"	12' to 15'	46'	47'	9'	15'	150'	10' 7"	13' 2"
Distance between lamps	14' to 18'	24'	32' to 38'	32' 9"	15'	12' to 25'	17' to 20'	14' to 18'	16' to 25'

(The meeting then adjourned until two o'clock in the afternoon.)

FOURTH SESSION

President Ferguson called the meeting to order at ten minutes after two o'clock, and announced the first business of the afternoon session to be the paper on "First Aids and Appliances," by Dr. J. D. McGowan.

Dr. McGowan presented the following paper:

FIRST AIDS AND APPLIANCES

I believe this is the first time in the history of this association that any paper pertaining to relief of the injured has been read at its meetings; and it is one of the gratifying signs of the times that the interests of others than the members of the medical profession are being awakened, not only to measures for the prevention of disease, but also for preventing, so far as it is possible to do so, some of the unfortunate results of either improper treatment or no treatment at all in cases of accident, whether of a serious or an apparently trifling character.

Owing to the prompt application of first dressings, in the late war between the United States and Spain, the records of the surgical department of the army and navy show a smaller percentage of loss of life or limb than in any previous campaign.

As all, or nearly all, of your shops are in large cities and towns where the services of a surgeon can be readily obtained, and no great amount of time need elapse from the moment of accident to the obtaining of skilled surgical aid, I will not go into an elaborate detail of all that should be done, as it is far better to do too little than too much.

If your shop is in Pennsylvania, you may have in your employ a young man who has a brother practicing medicine in Iowa, and such relationship is apt to make him believe he has the medical instinct which gives him a knowledge superior to his fellows. If you have such a man about, and an accident happens, send him for a doctor.

It is well to have on hand at all shops or factories a box containing the necessary articles for the application of first aid (such a box I will now pass around for your inspection), and have a few of your intelligent foremen instructed in their use.

When an accident happens:

Do not get excited.

Send for a surgeon; tell him briefly the nature of the injury.

Remove the injured man to a quiet, well-ventilated place, neither hot nor cold, away from the noise of the engine-room and machinery, and place him in as comfortable a position as possible; lay him upon his back, with his head on a level with his body, and his limbs in a natural position.

Allow nobody near except those who are needed to care for him.

Do not let him know that his condition is serious; encourage him all you can.

If the head has been injured, it should be raised somewhat higher than the rest of the body.

Loosen his clothing at neck and waist; if patient faints, lower his head and raise his feet.

If arm or leg is injured, it may be slightly raised and laid on a cushion; a cushion may be made with old clothing or any soft material.

If he vomits, or tries to do so, turn his body on one side, with the chin low, so that the contents of the stomach may flow from the mouth.

If the wound is found covered by clothing, cut the clothing in the seam and remove only enough to show the wound. In case of burns, pour lukewarm water over the clothing before attempting to remove it; otherwise you are liable to pull off the charred skin and leave a large, raw surface open for infection. Cover all wounds and burns as quickly as possible.

In examining a wound, wrap some antiseptic gauze around the fingers before touching it. Do not attempt to cleanse a wound; expose it and apply some antiseptic gauze, or the contents of this little package, called "first help for wounds," and wait for the surgeon to cleanse the parts.

BLEEDING

From the arteries, blood is bright red, and comes in spurts or jets, as from a small hose. This should be immediately stopped if possible, and the best method is to apply pressure over the artery at some point nearer the heart than the point of bleeding, selecting a place where the artery is near the surface of the body. I show you here a roughly made chart on which I have attempted to outline the course and position of the main arteries, pointing out the best location, according to nature of wound, to apply the pressure. First, apply several thicknesses of gauze over the wound (having fingers wrapped in a separate piece of gauze before handling), and bind tightly with roller bandage; then over the point selected between the wound and the heart, apply pressure, using anything at hand for the purpose—a piece of rubber tubing, such as is used for gas piping, is best, a pair of suspenders, a rope or a bandage; bind the parts tightly and leave them until the aid of a surgeon can be obtained.

From the veins, blood is of dark-red color and flows out or wells up freely from the wound. Apply pressure directly over wound, using wad of gauze and bandage.

When the blood oozes from the wound, apply gauze and bandage.

In case of bleeding, keep the patient in a horizontal position; if bleeding from a limb, elevate the limb; keep the patient warm. When bleeding has ceased, hot drinks may be given.

Do not leave tight bandage on a limb too long; the bandage may be loosened after fifteen minutes, and reapplied with diminished pressure. In rupture of varicose veins, elevate the limb, loosen clothing, and bandage firmly below the wound, and apply a compress over the bleeding vein.

When a man faints from loss of blood, lower the head and raise the limbs; be ready to apply compress, if bleeding starts up again. The method of arresting bleeding from special parts I can better illustrate than describe, and if I can find a willing victim in the audience to assist me in the illustration, I will occupy as little of your time as possible in showing how this is done.

Do not cover a wound with any dressing that is not sterilized.

Do not forget to elevate the limb.

Do not put on cobwebs, tobacco, or shellac, or salve.

Do not disturb blood clots.

Do not give whiskey or brandy.

Do not leave a wound uncovered after the bleeding has stopped.

For internal bleeding, apply ice-cold cloths to abdomen; lower the head slightly.

WOUNDS

In injuries to the head, place the patient on his back, with head resting upon a cushion covered with a clean towel.

The arm, when injured, should be brought across in front of the chest and supported by a sling.

The lower limb should be supported on a cushion or blanket.

In chest wounds, the head and shoulders should be raised by one or more pillows until patient can breathe comfortably.

In wounds of abdomen, patient should lie down, with knees drawn up and turned toward injured side; if wound be in front, place him on his back.

After covering a wound of any kind, do not uncover it; put on more bandages if it bleeds.

In bruises or sprains, apply hot water, as hot as can be borne; if an ankle is sprained, or foot crushed, place it in a bucket of hot water, keeping the water hot by adding more hot water as required.

FRACTURES

These may be simple or compound. A compound fracture is where there is an external wound communicating with the fracture. This may be caused by one end of the fractured bone penetrating through the skin, or by a spike or rifle ball or some other missile piercing the skin and tissues to the seat of fracture.

Place the patient in a comfortable position, supporting the injured member upon a cushion of some kind, which may be made with any soft material at hand. If possible to remove the clothing without causing much pain, it is best to do so. In simple fractures this is not absolutely necessary, as a splint can be applied over the clothing, using the latter for a pad.

In compound fractures, dress the wound with the contents of the first-aid packets, or with antiseptic gauze, before applying splint.

Do not attempt to set the bone; merely try to put the injured part in a position where it can be held securely, so as to prevent the fractured ends of the bone from rubbing together and causing pain.

SPLINTS

The chest can be used as a splint for the arm by binding the arm to the side with a roller bandage.

The uninjured leg may be used as a splint for the injured one.

A splint must be long enough to keep the joints above and below the injury at rest.

The splint should be a little wider than the thickness of the limb.

The splints should be padded with some soft material, such as sheet wadding, cotton, etc.

If two splints, one on each side of the limb, can be applied, all the better.

Material for splints is usually easy to obtain: cigar boxes, pasteboard, laths, shingles, barrel staves, broom handles, canes, shovels, umbrellas, desk rulers, fruit baskets, etc. Any of these may be used.

Place the splint on either side of the injured limb, have the splints well padded and secure them to the limb with a roller bandage, or a handkerchief; towels, suspenders, cord or straps may be used if the bandages are not at hand.

Some one should support the limb by slipping the hands gently under it, above and below the injury. while the others are applying the splints.

In fractures of the skull, place patient on his back with head and shoulders slightly raised, and keep quiet until surgeon arrives. If there is a scalp wound, place some antiseptic gauze over the wound.

In fractures of spine, keep patient flat on his back.

In fractures of collar bone, place pad under armpit, and bandage arm to side. Patient is best on his back.

In fracture of ribs, patient should be moved as little as possible. Keep head and chest elevated; let him lie on his back or on the uninjured side.

In fracture of thigh, apply a long splint made of board, to extend from below the foot to above the hip, first drawing the limb out to its full length, and bandaging the splint to the leg at the ankle, the knee, and about the waist.

In fracture of knee-pan, place a pad in the hollow under the knee and apply a splint to the back of the leg, keeping the leg straight.

In fracture of leg below the knee, place the leg gently in a pillow and bind the pillow to the leg. If no pillow is at hand, apply a board splint (taken from a fruit basket) to either side of leg and bandage, being careful not to bandage too tightly.

If a patient is to be carried some distance, bind the injured leg to the other limb, after applying splints.

In fracture of upper arm, place a pad in the armpit and draw the elbow to the side; bind the upper arm to the side of the chest and put the fore-arm in a sling.

In fracture of fore-arm, make a splint from a cigar box, or a piece of wood long enough to extend from the fingers to near the elbow; place this on inner side of arm and another piece over the back of arm, and bandage.

In fracture of fingers, bind one finger to the other, after placing card-board splint under the fractured member.

BURNS

Burns are of three degrees:

First—Simple reddening of the skin.

Second—When blisters form.

Third—Charring of skin and ulceration.

Remove clothing carefully; cover burned surface quickly to exclude air; pour on oil. A mixture of equal parts of linseed oil and lime water forms the best and most convenient dressing for first aid, and should be kept on hand, in well-corked bottles, in every shop where a workman is liable to be burned. Pour this freely on the surface, apply sterilized gauze and saturate that, then a layer of absorbent cotton, and soak that with the oil. When the burn covers a large surface, expose and dress a small area at a time. When a man's clothing is on fire, throw him down and roll him over to extinguish the flame, or wrap him in a blanket, or some woolen material, and press the burning points from the outside.

If no oil is at hand use a warm solution of baking soda in water; or use white of egg, or powdered starch, or toilet powder.

When a burn is very extensive, and patient is in a state of shock and grave danger, if there is a bath-tub available, wrap him in a sheet, clothes and all, and lower him into the bath-tub, which should be filled with tepid water. He may be kept there many hours with his head above the water. This is the best method to relieve pain and to prevent the danger from shock

Burns from ammonia, lye, etc., should be bathed freely with water, then with vinegar, and then with oil.

Burns from vitriol or other acids should be washed with water, then a solution of soda or lime water, mortar or chalk may be used; afterwards apply the oil.

A fragment of lime in the eye should be washed out with water, and the eye bathed with a weak solution of vinegar or lemon juice.

TRANSPORTATION OF WOUNDED

The four-handed seat is made by two persons clasping each other's wrists, as I now show. Doubtless many of you have done this in your boyhood days at school.

After the hands are clasped together, the bearers stoop down behind the patient, who sits on the hands, and places one arm around the neck of each bearer.

The two-handed seat is made by two bearers clasping their hands and placing their free hands on each other's shoulders. A bearer stands on each side of the patient and passes one arm under his knees and clasps the hand of the other bearer; the bearers then pass their arms around the back of the patient and grasp each other's shoulders.

The "pick-a-back" method may also be sometimes used. A temporary stretcher may be made by turning the sleeves of a coat inside out; two stout poles are then passed through them and the coat is buttoned. The patient sits on this and rests against the back of the first bearer. To make a longer stretcher, treat two coats in the same way.

Two sacks may be taken; a hole is made in each corner of the bottom, and two poles are passed through the sack and out of the holes.

A broad board or shutter may be used as a stretcher; if used, some hay, straw or clothing should be placed on it, and then a piece of stout cloth or sacking; the sacking is useful in taking the patient off the stretcher. Always test the stretcher before using.

Never allow stretchers to be carried on the bearers' shoulders.

Always carry patient's feet foremost, except when going up hill.

The "first-aid package," or "accident case," which I have shown you, contains many things that are invaluable to the layman in applying relief to the injured; there are also some articles contained therein which none but a surgeon should be permitted to touch, such as needles, sutures, etc.

If, however, the surgeon, hastily summoned, should have omitted to bring with him all the requisites for cleansing, suturing and dressing a wound, it would be very gratifying to him to find everything ready for him in such a convenient, compact form.

I wish to show you also the Chicago Edison emergency box, the product of Mr. W. L. Abbott's ingenious brain. One of these boxes is carried on each wagon.

It contains a box of Edison ointment, of whose healing properties we are justly proud, a gauze bandage, a first-aid package, a hypodermic syringe, and a solution containing one-twentieth of a grain of strychnine to each barrel of syringe. The strychnine is to be used to inject under the skin of a man who receives a shock from the high-tension wires. If a doctor is near by, it is well to have the solution ready for him; in the absence of a doctor the foreman is instructed how to use the syringe.

SHOCK

Shock is common after serious accident, injury, burn, or from the electric current.

The symptoms or signs of shock are cool, clammy skin, vomiting and retching, weak, rapid pulse, sighing or irregular breathing, half-opened eyelids, dilated pupils, dullness of intellect and sometimes insensibility.

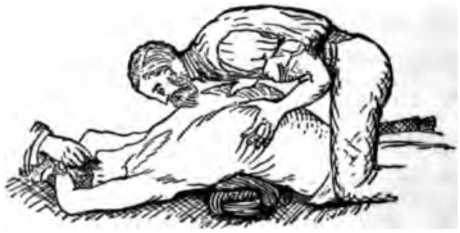
Place the patient in a warm, quiet place; after dressing wounds, wrap him in warm material and apply heat to the whole body, using hot-water bottles, water-bags, hot bricks, blankets, flannels wrung out of hot water (no heat to head), hot drinks (coffee best), spirits of ammonia diluted with water, or small amount of whiskey.

Electric Shocks. Susceptibility to shock depends upon the individual; women and children being less resistant than men. Diseases of heart and kidneys predispose to accident from electric shock. Do not lower the head of a person who has received electric shock. Artificial respiration should be kept up for hours. Massage of abdomen and left side over the heart. Heat to body as above.

Remove patient to a room in some adjacent house; remove most of his clothing; apply hot-water bottles to body and limbs, wrap feet in hot wet cloths. Apply artificial respiration as shown below. Do not get discouraged if patient does not shown signs of life; keep up the work for several hours. Men have been brought back to life after ten hours of hard work, so work on patiently and constantly and you may bring back a fellow workman who is apparently dead.

Artificial respiration is produced as follows, whenever it is required: Face upwards; the hard roll of clothing beneath thorax, with shoulders slightly declining over it; head and neck bent back to the utmost. Hands on top of head; (one twist of handerchief around the crossed wrists will keep them there); rip or strip clothing from waist and neck; kneel astride patient's hips; place your hands upon his chest, so that the ball of each thumb and little finger rests upon the inner margin of the free border of the costal cartilages, the tip of each thumb near or upon the xiphoid cartilage, the fingers fitting into the corresponding intercostal spaces; fix your elbows firmly, making them one with your sides and hips; then—

Pressing upwards and inwards towards the diaphragm, use your knees as a pivot, and throw your weight slowly forwards two or three seconds until your face almost touches that of the patient, ending with a sharp push which helps to jerk you back to your erect kneeling position. Rest three seconds; then repeat this bellows-blowing movement as before, continuing it at the rate of seven to ten times a minute; taking the utmost care, on the occurrence of a natural gasp, gently to aid and deepen it into a longer breath, until respiration becomes natural. When practical, have the tongue held firmly out of one corner of the mouth with thumb and finger armed with dry cotton rag. Avoid impatient vertical pushes; the force must be upward and inward, increased gradually from zero to the maximum as the age, sex, etc., may indicate. Abandon no case as hopeless within an hour's useless effort.



The following methods may be employed: (1) lay the patient on his back, with the shoulders elevated, draw the tongue forcibly forwards, grasp the arms at the elbow and carry them upwards firmly until they nearly meet above his head, then lower them to the side, and make firm compression upon the lower part of the breast-bone; repeat this process twelve to fourteen times in the minute. Or (2) turn the body gently and completely on the side and a little beyond, and then on the face, alternately; repeating these measures deliberately, efficiently, and perseveringly, fifteen times in a minute.

DISCUSSION

The President: Gentlemen, you have heard the paper of Dr. McGowan, and it is now open for discussion. I think Mr. Lieb has a communication along this line, and we shall be glad to hear from him.

Mr. Lieb: Dr. McGowan has given such an able and comprehensive treatment of the subject, that it would only be taking up your time unnecessarily to present a few notes that were prepared by the physician of the New York Edison company, covering much the same ground, though much less exhaustively than Dr. McGowan's paper. I will hand these notes to the secretary for incorporation in the minutes.

As I am on my feet, I can not help congratulating Dr. McGowan on his admirable presentation of this interesting subject; a subject perhaps foreign to the usual programme, but which shows that we all have the welfare and health of our men at heart. I am sure that every one who has heard Dr. McGowan's remarks will have gained some useful and valuable information that will redound to the benefit of the employees of the company he represents. I feel particularly grateful to Dr. McGowan for his emphasis on the persistence of efforts at resuscitation, and that these efforts be extended over a considerable period of time until all hope shall have disappeared. We must all feel very grateful to Dr. McGowan for his admirable presentation of the subject.

Mr. Gille: It seems to me that it would be wise for the association to consider the matter of publishing this paper for distribution, so that it will get into the hands of the employees of all the companies represented. It is very important, and I think that nearly all employees who handle the high-tension current do not appreciate the fact that keeping up efforts for resuscitating persons who have been in contact with electric currents oftentimes meets with success. I should like to see the paper printed so that it can be distributed among the employees of the various companies, in order that they may become familiar with it. I make that as a motion.

(Mr. Gille's motion was carried.)

MR. LIEB: I wish to ask Dr. McGowan a question, and that is, if it is a fact that an electric burn is much more serious and difficult of cure than an ordinary burn, and, if so, why?

DR. MCGOWAN: The electric burn is entirely different from an ordinary burn, such as you get from a flame or from scalding water. It depends on how you get the burn. If you make a short-circuit and get a flash burn, the treatment of that burn is the same as the burn from any flame—from fire of any kind; but if you get a contact burn, where you put your hand on something that has live current, the current passes through the tissues and destroys the tissues through which it passes, the time of contact determining the amount of injury that is done. If the contact is short, the current does not penetrate very deeply through the tissues. I have a man under my care now whose finger I am going to amputate to-morrow. He is a carpenter, and was working behind the switchboard. He stepped upon a regulator and grasped an iron bar with his hand. He did not get away until released by one of the men after the current had been shut off. The current passed into the finger on both sides, near the knuckle of the hand, and destroyed everything to the bone. As the blood vessels were burned through, the circulation of blood through the finger ceased and gangrene set in. He has also a large burn on his leg. The dead tissue sloughs or rots away in the course of two or three weeks, and then the new tissue grows and fills in the space. This process of repair takes a long time. An ordinary flame burn, or flash burn from short-circuit, ought to get well inside of two or three weeks, but severe electric burns take two or three months to heal—sometimes longer—on account of the destruction of tissue.

MR. J. D. DUSMAN (York, Pa.): What ought to be done in case of a flash in front of a man's eyes? I have suffered twice from such flashes. No evil effects followed, because I was in each case close to an eminent oculist. What should be done in a small station in such a case?

Dr. McGowan: Cases of burning of the eyes from flash are frequent. The best thing to do is to drop some sweet oil—which must be perfectly clean, or some castor oil, if the castor oil is perfectly pure and sweet—into the eye, then a solution of boracic acid, and to ease the pain use a little cocaine. Take some boracic acid and put a little in water—it does not make any difference how much you use, because you will get only a certain strength—and make a saturated solution of boracic acid, and drop that into the eye every hour or two. If the pain is severe put in a little cocaine, two-per-cent solution, to relieve the pain. Continue this treatment for a few days and the eyes will be all right.

Mr. Jackson: There are some cases where the shock apparently produces spasms, and under those circumstances the men, as a rule, know absolutely nothing of what to do. I should like to know what should be done under such circumstances before the doctor comes. I know of three cases where the shock seemed to produce nothing further than spasms, and in one case these continued for three hours.

Dr. McGowan: The best thing to do under those conditions would be to put the man in a hot bath, as hot as he can bear it ; do not move him ; keep him quiet and bathe him. If you have no place in which to bathe him, wring out some cloths in hot water and put these over his body. That is the best thing to do until the doctor comes.

Mr. Bertrand: In case a man is badly shocked and no assistance is available for some length of time, how long after the shock would it be worth while to administer artificial respiration ?

Dr. McGowan: That is pretty hard to say. If you reach the man within half an hour after he has had the shock, I think it would be worth while to take measures to bring him to life ; after half an hour it would be useless to make the attempt.

Mr. Lewis: We had a case of very severe burning a few weeks ago. A man undertook to pull the plugs on a board and grasped the handles in such a manner that his index fingers touched the brass ferrules. On taking hold of the plugs he unlocked one of them. The dead short-circuit made him unconscious, and the unlocked plug came out as he fell, and saved his life. After some time he came to, but his fingers were burned to the bone. He had a physician dress them for three weeks, with but little improvement. One of the men at the power-house suggested that he use powdered bismuth. This he did, and found that the affected parts healed very rapidly, and he was able to do his work in a very short time. It occurred to me to suggest the powdered bismuth, so that it might be tried by others.

Mr. Burt: Two of our men were pulling out a wire and it accidentally became crossed with a 20,000-volt line. One of the men let go and the other maintained his hold. He is alive and well to-day, due to the fact that the wire he held was stretched for several rods on the ground, and to the promptness of the foreman, who took off his coat and wrapped it in a bundle in such a way as to protect himself and then wound it around the wire and pulled it out of the man's hand. The man was insensible, his tongue protruded, and he was black in the face. The foreman simply stuck his finger into the man's mouth and released the tongue so that he could get air, and then worked over him for quite a long time. The man came into the office an hour and a half later, and although he had 14 burns from head to foot and it took him four months to recover, he is alive and well to-day.

Dr. McGowan: I will simply remark, in closing, that if you will insist on the men wearing rubber gloves when they are at work you will save a lot of expense.

CONTRIBUTION BY DR. JOHN WOODMAN, COMPANY PHYSICIAN OF THE NEW YORK EDISON COMPANY, TO DISCUSSION OF DR. McGOWAN'S PAPER:

Each station of the New York Edison company is supplied with a medicine chest supported from the wall by brackets. This medicine chest has several shelves, is provided with a glass door, and contains the following equipment:

One-half pound of absorbent cotton
One-half dozen 2½-inch gauze bandages done up in individual papers
One-half dozen 2-inch " " " " "
One-half dozen 1½-inch " " " " "
Carron oil
Linseed oil
Lime water

Carron oil mixture is particularly good for burns, and its use is generally understood by the workmen. It should be supplied in quantities not greater than one quart at a time. It is very important that the lime water used be fresh.

For an antiseptic cleansing and soothing solution, suitable for open wounds or burns, one teaspoonful of carbolic acid and one teaspoonful of borax, well mixed in a pint of pure water, is found to be excellent for general use.

Where there is not too great pain it is well to apply dry dressings and allow the physician to properly clean up and dress the wound upon his arrival.

Where there must necessarily be considerable delay before the arrival of medical assistance, the wound should be dressed as well as possible with clean waste or the cleanest cloth obtainable in the absence of regular bandages.

The application of sticking plaster by moistening with saliva and the time-honored custom of applying the tobacco quid are to be condemned. Avoid mopping the wound, as it interferes with clotting. A tourniquet should be applied only when other means fail.

Hemorrhage is best stopped by elevating the part affected and using direct pressure.

Tinctures of iodine and arnica must not be used on fresh injuries.

Infected wounds are often wrongly attributed to copper dust. Salts of copper are slightly irritating but antiseptic.

For sprains, bruises, and even for fresh cuts, we use folds of bandages of absorbent cotton wet in Pond's extract of witch hazel, and apply the bandage firmly, to prevent undue swelling or either deep or external hemorrhage.

Fireman's cramps are almost invariably due to drinking too much iced water, and cholera drops should be given rarely and never continuously, as they contain opium.

Heat-stroke cases do not ordinarily occur in men who are well when they go into the fire-room. Until such patients can be taken to the iced bath in the hospital they should be rubbed with ice and iced water in a good circulation of air.

For electric shocks, we have illustrated and descriptive charts showing methods of artificial respiration.

THE PRESIDENT: We will now take up the paper on "Steam Turbines," by Professor William Lispenard Robb, of the Rensselaer Polytechnic Institute, Troy, N. Y.

(Professor Robb read the paper, which was illustrated by proportion of the work done by steam in expansion in engines or turbines is done by virtue of the latent heat in the portion of water liquified in the process. In a turbine of the Parsons type steam passes on through the machine. If the machine is inefficient in its functioning, a large portion of water will be re-evaporated, and we have a condition where the final discharge is almost superheated. In the Curtis turbine the water is taken out of the successive stages in greater or less proportion and does not take part in the subsequent expansions, and consequently all the superheat that can be had is available; in other words, the steam is allowed to act efficiently without having to expend its energy in re-evaporating the water. Our knowledge of the Curtis turbine is limited, because we have only been able to test certain sizes and forms; but, so far as we have gone, we see that either the elimination of initial moisture, or moisture in any stage, or the addition of superheat, are equivalent benefits to the turbine, and the improvement with increased superheat seems to hold up to a very high degree at a fixed rate. When we introduce the superheat in the first stage of the two-stage turbine, we tend to dry the steam in that stage, but it may be wet again at the discharge end of the stage. The next stage, however, may be almost equally benefited by the elimination of moisture that might otherwise go to it.

Our hopes for the future economy in turbines of this type, which are very strong, are based to a great extent on the proper elimination of this moisture and the proper use of this superheat. We know that under certain conditions we get very high efficiencies in the functioning of the turbine; that is, the blowing of the steam through the buckets gives under favorable conditions a large proportion of the energy that the steam carries.

Concerning large and small turbines, Professor Robb stated that the large turbine and the small turbine were almost equally good. I told him that, and it is true to a certain extent; that is, we know that the small turbines are good; we do not know how good the large ones are. We have reason to hope that with the large-sized machines we shall get great gains; particularly with the Curtis machine, because there we have a certain amount of clearance necessary for mechanical reasons and that clearance can be made of less proportion to the whole steam passage where the turbine is large, and the leakage and dissipation through improper fittings would be relatively less, and all the friction and radiation losses are very much less. We hope to get very much better results, although we do not make any promise beyond our positive knowledge. The turbine that is to be installed in Chicago is larger than anything we have tested for steam economy. We have tested machines as high as 600-kw capacity, and in a paper that I read some time ago I gave some curves. Professor Robb has repeated some of the curves, showing the performance of the machine. This machine, under conditions that we know to be practicable in any station where there is condensing water, shows a consumption of dry steam of 19 pounds per kw-hour, 600-kw unit, and only a pound and a half worse at half load. This result is so much better than existing results in steam-engine stations that it shows the turbine is a reality. The machine to be installed in the station that you will see this afternoon has not been tested, except in a mechanical sense. It has been running in Schenectady with steam exhausting into the atmosphere, running core-loss tests, and developing normal voltages on the machine for ordinary electrical tests without carrying load. The functioning has been perfect, the governor acts perfectly, and all its mechanical functions are satisfactory; and we hope the machine will come into use without any delay or confusion.

The discussion on the steam turbine was postponed until the next session of the convention, and at four o'clock the convention adjourned until Thursday morning, in order to give the delegates an opportunity to visit the station being erected by the Chicago Edison Company.

ORDER OF BUSINESS

THURSDAY, May 28th, 1903

FIFTH SESSION, 10.15 A. M.

1. Report—District Heating. JOHN W. GLIDDEN
2. Discussion of Professor Robb's Paper on Steam Turbines (Continued)
3. Paper—"Salt as a By-Product." By ALEX DOW
4. Paper—"Some Fundamentals of Photometry." By PROFESSOR H. E. CLIFFORD
5. Report—Committee for Investigating the Photometric Values of Arc Lamps. HENRY L. DOHERTY, Chairman
6. Report—Decorative and Sign Lighting. ARTHUR WILLIAMS

SIXTH SESSION, 2.20 P. M.

1. Paper—"Relative Advantages of Electrical and Mechanical Methods of Speed Control for General Power Service." By WILLIAM COOPER
2. Report—Theft of Current. ROBERT ELLIOTT

3. Report—Lost and Unaccounted-for Current. L. G. Van Ness
4. Question Box—H. T. Hartman, Editor
5. Report—Committee on President's Address

EXECUTIVE SESSION

1. Amendment to Constitution
2. Report of Secretary and Treasurer
3. Election of Officers
4. Report—Committee on Standard Rules
5. Resolution for Special Meeting at St. Louis

FIFTH SESSION

President Ferguson called the meeting to order at a quarter after ten o'clock, and stated that the Potomac Electric Power Company, of Washington, D. C., was anxious to learn if 500-volt power circuits were in use on the systems of any of the members, and if so, the names of the companies. This question should have gone into the Question Box, but was received too late. It was requested that all members who had knowledge of such circuits write to the Potomac Electric Power Company.

The report on District Steam Heating, by Mr. John W Glidden, of De Kalb, Ill., was then read, as follows:

REPORT OF COMMITTEE ON DISTRICT HEATING

Your Committee on District Heating finds that there are about one hundred heating plants of this character in operation in the United States at the present time. Possibly ten of these are live-steam heating plants, operating solely for the heating business. The remainder are about two-thirds exhaust-steam heating plants, and one-third hot-water heating plants. A list of questions was mailed to all of these plants, to which about fifty replies were received. Twenty-two were regular blanks partly filled in; the rest were letters stating they could not give the information or did not wish to give it. Quite a few have been in the business but a few months. When this circular was gotten out, it was my intention to sift and tabulate this information in such a manner as to demonstrate the actual basic conditions under which each plant is operating. For example, a plant operating with a simple engine, under a back pressure of ten or fifteen pounds, was to be compared with the operating conditions of the same plant, supposing that the money expended in installing the heating mains had been judiciously spent in improving the engine and boiler plants. It was also intended to ascertain whether general expense items were properly distributed. The nature of the replies, and other matters that I shall treat of later, show this to be impracticable at this time.

TABLE SHOWING SOME DATA

No.	Investment in Heating Plant	Heating Revenue	Price of Coal	Labor and Fuel for Heating	Total Coal	Back Pressure	Net Revenue per cent of Investment	Remarks
1	$75,000	$26,000	$1.00	$12,000	$31,536	3–15	18.7	Day load
2	4,800	2,000	2.40	......	......	0–0	....	Water-power
3	12,000	3,200	1.75	......	......	2–5	....	No day load
4	33,000	2,293	1.25	......	5,838	0–3	....	Day load
5	67,738	26,449	1.58	20,916	27,594	3–20	8.2	Day load
6	5,000	1,000	1.25	......	......	0–0	....	No day load
7	40,000	Just Std.	2.15	......	......	0–0	....	Day load
8	15,000	6,500	1.70	3,000	8,148	0–0	23.3	Day load
9	......	43,000	....	14,800	......	5–18	....	Live St. only
10	16,000	3,712	2.00	......	......	0–0	....	Day load
11	66,159	15,843	....	13,282	7,185	....	4.0	Live St. only
12	30,000	3,170	2.25	......	......	0–0	....	New plant
13	......	.....	5.00	......	......	....	....	Sore spot
14	48,000	10,000	.90	......	......	2–5	....	Sore spot
15	10,000	2,642	1.35	1,414	4,950	1–3	12.3	Day load
16	6,000	1,906	2.10	......	3,509	1–5	....	No day load

NOTE—Isolated office buildings use 100 pounds good Illinois coal per square foot of radiation during seven months heating season.

This table is put in not because of its value, but to emphasize the condition of the heating business. You can notice a lack of information in a majority of cases. This arises from two reasons: first, because they have not got it, and second, because they are afraid of the damage to their capital stock if the actual conditions of their heating business became known. A few extracts from letters received may serve to emphasize this. One man of several years' experience writes: "We are not in a position to answer your questions in any way that would be satisfactory to you." Another in business, writes: "Possibly next year we can aid you in this matter." Another: "I do not think it possible to give you the information, for various reasons." Another: "I receive many blanks from the National Electric Light Association. It would require more clerical work to fill out your blank than it would to make an annual report to the state; in fact, it can not be done, as we have not the data. I wish you would drop my name from the mailing list." Another: "I will bring this matter before the president of the company." Another: "We have learned much by experience, which is always expensive, and we do not care to contribute to the general knowledge." Another: "I feel that the matter requires more careful consideration than I have time to give it."

I believe this table and these letters show that this subject requires good, strong treatment by the association. I visited about twenty heating plants and personally interviewed the managers thereof, and inspected the properties. Aside from the plants located in the cheap coal belts, where screenings can be delivered for about $1.00 per ton, and a few other plants where the gross receipts are at least 60 per cent of the investment in mains, there is very little enthusiasm among heating managers. The representations which induce a great many of these men to go into the business have not proven out, and they are left with large plants which they are continuing to operate because they do not know what else to do with them.

Looking at the heating business from another standpoint, it is a question for the consideration of this association whether an investigation of the present conditions of the business, and the publication of these results, is broad enough in its treatment to take in all phases of the business. Personally, I became convinced, from talks with heating managers and from the merchants' plants, which are being installed, that even though it were demonstrated that the present conditions of the business would not warrant central-station men going into it, they would go into it, nevertheless, because the public has become so thoroughly convinced of the desirability and practicability of district heating, that if the central station does not occupy the territory, it will be occupied by merchants' associations. These associations will, at the same time, enter the lighting business and jeopardize the investment of the older company. It seems to me beyond dispute that there exists a very lively and pressing demand for heating plants. If we grant that this demand is to be met by some one, is it not fair to state that electric central stations are the best people to meet it? First, because of some available apparatus already installed; second, because they possess the technical knowledge; third, because they possess the organization; and fourth, for their own self-protection.

I recommend the appointment of a permanent committee to work continuously on the heating business. I think the association should decide on one or two methods of procedure: Whether this committee should continue to gather data to show what heating plants are doing, or whether it should investigate the losses in the heating business and devote its energies to the development of the business. A few managers are working out their salvation alone. If they would combine their efforts under the leadership of the committee of this association and arouse activity among those who are drifting at the present time, their united efforts would bring an early solution of many of the present difficulties. A uniform system of accounting and keeping data, with the inauguration of thorough testing to show what becomes of the actual heat units sent out, would clarify the business and remove it from the field of haphazard experiments and make it an exact science.

RECAPITULATION

First—I find no evidence that the business is generally profitable.

Second—A lack of information among heating managers.

Third—A lack of enthusiasm for the business.

Fourth—Little separate accounting.

Fifth—Genuine demand from the public for the services.

Sixth—I think a permanent committee should be put in charge of the heating business.

Seventh—I think this association should instruct this committee whether to devote its time to the investigation of the business as it stands, or devote its time to the promotion of the business by testing, and so forth.

JOHN W. GLIDDEN, Committee.

DISCUSSION

MR. C. R. MAUNSELL (Topeka, Kan.): I can indorse some of the things Mr. Glidden has said in reference to the heating business. I presume I am one of the persons who did not answer his letters satisfactorily. A great many of the questions were of such importance that I could not devote enough time to answer them all; answering a few of them would not do much good. I think the members of the association would appreciate this if they saw the list of questions. There is no doubt whatever, as Mr. Glidden says, that there is a manifest demand for the steam-heating business. In our town, the demand greatly exceeds the capacity of the station. We have had very nice returns from it in a financial way, not only from the heating business, but in the results to the lighting and power business. I feel, too, that a permanent committee would be a very good thing to investigate this subject and get some reliable data. I will do all I can to assist that committee. A great many of the central stations would like some light on this question. The heating business is in much the same situation that the incandescent lighting was 15 or 18 years ago.

The President: I think that, in view of what Mr. Glidden has said in his report and also of what Mr. Maunsell says, it is very apparent that this committee, or another committee, should be continued and the investigation be carried on so that we shall really get at the milk in the cocoanut. As it stands at present, Mr. Glidden has found it difficult to get really satisfactory information. If Mr. Maunsell will put his suggestion in the form of a motion that the committee be continued, with an enlargement, possibly, of two or more members, I shall be glad to put that before the convention.

Mr. Maunsell: I put that as a motion.

(The motion was seconded.)

Mr. D. F. McGee (Red Oak, Ia.): Before voting on this motion, I should like to make a few suggestions. Like several others in the heating business, I have come here to get all the information possible on this subject. I also realize the difficulty of securing any data at this time. I believe that any committee —even when authorized by the National Electric Light Association—without ample funds to work with will find it very difficult to secure data that will be of use to us. The average heating plant is not equipped with the proper apparatus for testing the efficiency of same, and the managers have not time—and in many cases not sufficient knowledge of the subject—to make a reliable test. A few of us have made tests in our own plants and know exactly what we are accomplishing, and we shall be glad to render all possible assistance to any committee that this association may appoint.

I also realize, with Mr. Glidden and Mr. Maunsell, the enormous demand all over the country for central heating plants. I have answered no less than 600 letters of inquiry on this subject in the last four years. We have had personal visits from central-station representatives from almost every state, from Kentucky to Washington. They are all anxious to get into the business because their customers demand it, and if they do not cover the ground some one else will do so and will naturally take up the lighting and power business also. In most cases this would leave the first party with an elephant on his hands. I merely mention this to show the predicament that faces some of us missionaries in this field. If sufficient money is placed at the disposal of this committee, I suggest that it be expended in testing a certain number of steam and hot-water-heating plants. We should then be in a position to compare the efficiency of both, under different conditions. To do this in a thorough manner will require a vast amount of work on the part of some one.

THE PRESIDENT: I would say, for the benefit of Mr. McGee and of other members, that the executive committee during this year considered this matter of sufficient importance to put $250 at the disposal of Mr. Glidden, with which to make an investigation. I have not heard how much of the money has been spent. I make the statement to show that we realize the necessity of having funds at the disposal of the committee, and I think it would probably be a good idea to leave that matter in the hands of the executive committee; the amount of money to be allowed for the investigation of this subject to be decided at their discretion.

MR. GLIDDEN: I did not find any opportunity to spend much of the money; only about $60. There seemed no way in which it could be spent to bring out any definite results without making tests, which it was too late to do.

MR. MCGEE: It is not at this time a discussion as to the merits of steam and hot-water heating, but we must all unite for an investigation of all systems, under difficult conditions. Data secured under those conditions would certainly be of value to this association.

MR. W. MCLEA WALBANK (Montreal, Can.): During the last few months I have given the question of district heating considerable attention from a commercial standpoint. I am referring to Montreal, where coal is probably dearer than on this side of the line. After writing to all towns where I could ascertain they were using district heating, and communicating with companies whose business it was to install same, I thought it advisable to test the locality that would be supplied by my company if we decided to go into the heating business, and endeavor to find out what it was costing the individual proprietors to heat their buildings at present. I took the district within a half-mile radius of our station and had a representative go over their books, coal bills, and other expense connected therewith, and ascertain what they were willing to pay us to supply the heat for them. As a result of our examination, we concluded that if we got our coal and attendants for nothing the probable returns would not pay interest on the investment for the pipes alone, consequently we dropped the matter.

MR. MAUNSELL: I ask the gentleman if it is not a fact that he intended to operate the steam-heating plant more as a live-steam plant, or as an auxiliary to his water power; if this is not the reason he decided against it? We have been in the business for six years. We have $40,000 invested in our underground mains. Last winter we had a revenue of nearly $15,000, sufficient to pay all the coal costs of the plant for eight months and leave nearly four per cent interest on the money. I do not know of any better argument I can bring up than to say that in order to keep from making too great a showing on the steam heating we charge to it everything possible and still find that the operating costs of the steam heating are only something like 29 or 30 per cent of the gross revenue from heating; and I feel pretty certain that on the meter system, which is the only way to sell heat, for the same reasons that we sell light and power on meter, we should show even better results. My experience has been very limited in the matter of depreciation of the steam mains. We have had practically no trouble. We have had no costs for repairs, and when we made examinations for deterioration we found very little after six years' use. I think this question is very important to every lighting and power plant that has a day load, and one that will repay the association for any investigation that may be made concerning it.

MR. JAMES E. PYLE (West Chester, Pa.): I am very much interested in this question of steam heating. About a year ago we concluded to put in a steam plant at West Chester, and we installed 4,000 feet of mains varying from 5 to 12 inches in size. We operate an electric plant that has some day load, and we took on about 50 customers or more and did practically all our heating during the winter with exhaust steam. We used less than $200 worth of coal for live steam, and we operate the system during moderate weather with about a pound and three-quarters of actual pressure in the power-house. During severe weather it would run up to three and three and a half pounds to supply a plant some 3,000 feet away, and the outfit was not exactly what it ought to be. It required more pressure at the power-house on account of that installation than for any other customer on the line.

Regarding the fund that has been mentioned, I think, judging from the report we have heard, that if we want to derive any benefit from that investment it will be necessary for the members of the association who are interested to try and get some information. The information that could be gained might be of great value, but if the reports are such as we have heard this morning the money spent will be of little avail. I think it is our duty to make reports that can be of some use; we should put ourselves to some inconvenience and expense, if necessary, to furnish these data. One gentleman spoke of the cost of the meter that would be required to make tests in a hot-water system. We can all look back to the time when our power-houses did not contain wattmeters; we did not have the facilities for measuring the output of our stations and did not really know what we were doing. I think we all got to the point where we decided that it was very essential to have station wattmeters, that we might know what we were doing in the electric-lighting business; and if we are going into the steam-heating business, it is just as necessary to supply ourselves with the needed apparatus, so that we may know what we are doing in that line. I think I can say that in a hot-water system it would be hard to determine the losses in the plant in the way of radiation of heat, etc., in the street mains. In a steam plant, if the manager will go to the expense of putting water meters on all the drip pipes in the street he can determine the amount of loss. So far as the question of the system being profitable is concerned, it all depends very much upon the location of the steam plant; whether or not it is close to the locality where you want to distribute steam; whether you can operate largely with exhaust steam or not. If you have no day load, it is evident that it will take a great deal of live steam to supply the customers.

Another thing that cuts some figure is the comparative cost of steam coal and domestic coal. With us the price of steam coal is about one-half that of domestic coal. In some places it is different, and in those cases they have the advantage of us. So far as depreciation on these lines is concerned, we have had opportunity to look into some places that have been in operation 12 or 13 years, and it has been found that the wooden log is beginning to rot to some extent, but not very much. The location has more than anything else to do with the general proposition. If you have to run a long main from the power-house out to the distributing system, you will have to invest a great deal of money in the main. I have found that customers are willing to pay more for the service after it has been in the building awhile than they are at first willing to offer. I have found, as a general thing, when negotiating to supply steam heat, that prospective customers say they heat their buildings on about one-half the coal they actually use, and after the steam has been supplied and the bills begin to come in monthly they raise an outcry against the charge. But they continue to use the steam; it is more convenient and more satisfactory generally. Another thing I have found is that people do not realize how much heat they require during the colder months of the winter. They get their supply of coal in the summer or autumn and put it in the cellar, and they are not aware of the amount of coal consumed relatively each month of the winter season. The bill for the first month of the fall season is satisfactory, but when the bill for January is presented some protest is made, because they do not stop to think that they use three times as much heat during the month of January as during October and November or March and April. These are some of the things we run up against in the steam-heating business, and they are like many of those that we meet in the electric-lighting business. I find that both businesses work out on about the same lines. The same treatment of our customers in a business way seems to answer in our case very nicely.

MR. GILLE: It may be interesting to the members to know that Professor Carpenter, of Cornell University, has made many tests on heating and has published the results of his experience in book form. The book is very interesting.

MR. McGEE: We know from experience that it is not a difficult matter to get heating customers when your plant is installed; the great trouble is to keep them off your lines and to keep from extending your lines until you have an enormous investment tied up in street mains. At the present prices there is no money in live-steam heating, and I am not in favor of taking on any more radiation than we can heat with exhaust steam at the peak of our electric load in the coldest weather, and supplement with live steam during light load when necessary to do so. By adopting this plan, we are able to get a very substantial return from our investment. The public demands this service and some will go into it, and it remains for the central-station manager to decide whether he wants to take it up or see his business injured by some other party.

THE PRESIDENT: Do you figure anything for depreciation and interest?

MR. McGEE: Six per cent for depreciation and six per cent for interest per year.

Mr. McCabe: Why do you fear to go ahead and put in more mains?

Mr. McGee: Ours is strictly a commercial load and we are in the heart of it. We get a large building every 22 feet. If we extended our mains at all we should have to put in four or five miles of pipe and not get more than two or three customers to the block. This would require a very large investment to take care of the business. We have installed 50,000 feet of radiation on one and one-quarter miles of mains. We operate a 24-hour circuit, and figure upon using only our exhaust steam for heating purposes. If we install more radiation, we shall be compelled to use live steam. With coal at present prices our rates for heating will not permit us to do that at a profit.

Mr. McCabe: A plant in Pennsylvania in which I am interested is in somewhat the same condition. About two years ago they installed steam heating by exhaust steam, having a mile and a quarter of mains, and supplying about 75 customers. Last year the total income was something greater than the total amount expended for coal in the plant. The people wanted more of the steam heating, but the company did not want to extend the mains. They said the investment was as much as they could stand, and if they put in further mains they would not get sufficient revenue to meet the interest and fixed charges on the investment, as the present supply of exhaust steam during the minimum load on the engines is just about equal to the demand, so any further supply would have to be met with live steam.

Mr. Brine: During the last steam-heating season we had installed 15,000 feet of mains, to which we had connected about 200,000 square feet of radiation. While we do not think we made any money, we believe the furnishing of steam heat is of great assistance in securing business for the central station in places where isolated plants would otherwise be installed. We figure that the pounds of coal used per kw-hour were about one-third more on account of our steam heating than they would have been without it. We are now installing about 5,000 feet of additional mains, and hope to be able to take on about 200,000 more square feet of radiation with only a slightly increased cost, as we anticipate that the new arrangement of the mains will give us a better circulation, and there will not be any material increase in the back pressure.

The President: The opinions on this subject do not seem to be very definite, and it rather seems that the reason some of these companies are making a profit is because they are supplying the immediate neighborhood, and simply utilizing their exhaust steam. They are not in the heating business solely as a heating proposition, but as an auxiliary proposition. When they extend the mains into larger territories, and take on a large number of houses, and have to use live steam, there is quite a question as to whether or not they are making money. It leads up to Mr. Glidden's recommendation in his report, where he says: "If they would combine their efforts under the leadership of the committee of this association, and arouse activity among those who are drifting at the present time, their united efforts would bring an early solution of many of the present difficulties." There is no use in going ahead with this committee and spending money for the benefit of the members of the association, unless the member companies who are operating steam-heating plants are willing to give to the association at large the information they possess. The object of the association is to disseminate knowledge among its members. If any one has knowledge he should contribute it to the association at large, so I would beg of you—those of you who are operating plants—to be kind enough to give this committee, if we continue it, all the information you have at your disposal. You certainly can not lose anything by it, and I assure you that if you give the information you will receive back information tenfold in return. There is a motion before the house to the effect that this committee be continued for the purpose of investigating the subject further.

(The motion was put and carried.)

THE PRESIDENT: I think the question of expenditures in connection with the work of this committee on heating plants should be left to the executive committee. The executive committee will not waste the money, and they will see that it is spent intelligently.

THE PRESIDENT: We will now devote a little more time to the discussion on steam turbines, which was cut off yesterday afternoon. Has Mr. Emmet anything more that he desires to say on the subject of turbines?

MR. EMMET: Mr. President, I do not think I have anything more to say, beyond the fact that I shall be glad to answer any questions that may be asked me. The subject is such a large one that it is difficult to know where to begin on it. If I undertook to speak without any guide, I might talk all day and not tell the members what they wanted to know.

MR. GLIDDEN: What is the difference in the capacity of steam turbines when you use superheated steam and saturated steam?

MR. EMMET: In a turbine of the Curtis type, the capacity is practically unlimited, without any increased expense, because by simply adding additional nozzles you can get more out of the turbine; and for a given number of nozzles with superheat the capacity would increase somewhat with increase of economy. In the turbines that we have tested, increase of economy seems to be about one per cent for 12 degrees of superheat. That is only the result of tests to a very limited extent on one turbine, but it conforms pretty well with our expectation, although it would be different with other turbines. The increase of capacity will be less than the increase of economy. This is true only within limited degrees. I spoke more particularly of condensing turbines, with which the space for the exhaust steam is very large, and while the effective vacuum would be less with an increased volume of steam, there would still be space for a very large degree of expansion in the steam. The turbines are designed for a very high degree of expansion, and space is provided for it, and with a much greater amount of steam the amount of expansion is still very large; and while the economy would fall off finally, they are adapted to ordinary variations, such as are generally required for overloading generators, where the capacity is available. The turbines are ordinarily proportioned very much the same as large steam engines in this respect. By cutting off long on steam engines you can get a large overload capacity, and we have attempted to make the turbine to give the same results.

MR. MAUNSELL: What would be the effect of the back pressure on the capacity and economy of a 1000-hp turbine?

MR. EMMET: Back pressure is rather more objectionable in the turbine than in the steam engine. The turbine is relatively less advantageous non-condensing than condensing. One of the great advantages of the turbine lies in its ability to use the energy of high degrees of expansion, and when we work on non-condensing basis we lose that advantage, and we work on a basis parallel to that of the non-condensing steam engine. Under this condition the turbine must be considerably elaborated and made very perfect in its functioning in order to produce as good results as the non-condensing engine. In point of fact, up to the present time no turbine has produced as good results as those obtained from good non-condensing engines under similar conditions; this difference will be somewhat more marked if we use some back pressure. The turbine, however, will compete with the engine in the non-condensing field; there is no doubt about that. This result will be obtained by elaborating the turbine somewhat and making it better for that purpose, and we know it is possible to do this. Furthermore, the simplicity of the turbine, its good light-load economy and good overload capacity, will make it compete with the non-condensing engine. Up to the present time little or nothing has been done in that direction, and nearly all commercial turbine work to-day is done on the condensing basis.

MR. J. C. GILLETTE (Evansville, Ind.): How is the governing of the turbine accomplished—the cutting off of the steam?

MR. EMMET: The Curtis turbine has what we call a sectionalized nozzle; simply a long segment of the periphery covered with nozzles. We govern by simply cutting them off successively. The cutting off is actually done by the steam. We have a valve on each delivery passage and that is operated by a little piston, and the governor works a controlling valve that delivers steam to the piston and forces open the main valve. They keep opening and shutting automatically. To reduce the number of openings and closings of these valves we sometimes use a throttle on one section with a lost-motion arrangement that keeps the throttle drifting on that section, so that any fixed condition of load, instead of being got at by intermittent action of the valve, will be got at by some definite number of valves open with one partly open. In some cases the opening of the valves is so infrequent with ordinary governing that there is no object in using the throttle.

MR. HAROLD ALMERT (Oak Park, Ill.): The steam men generally seem to be interested in the introduction of the steam turbine: but there is one point that has not been touched upon, namely, the gas engine in large units. I am informed that in Berlin they have engines of 3,000 horse-power, taking 25,000 B. T. U. coal, converting it into gas, and getting an efficiency of one pound per hp-hour. A large steam-engine concern in this country has recently obtained the rights to the German patents in this country, and will have such a unit in operation at the St. Louis Exposition. I ask Mr. Emmet if he does not consider such a gas engine a serious competitor of the steam turbine? The steam men in this part of the country seem to be more interested in the gas engine than in the steam turbine.

MR. EMMET: I think the gas engine has a future. I think there is reason to believe that it will be used to a large extent in Europe before it is used here. Gas engines are expensive to build and maintain, and this is much against them. They produce a high fuel economy; but the best development of the turbine also produces high fuel economy. I have seen recent reports of the tests of the Parsons turbine in Europe that show astonishing economy at high degrees of superheat. The best turbines will do almost as well in fuel economy as the gas engine, and with infinitely simpler methods and less maintenance in the turbine. I think the gas engine will receive a long setback because of the development of the steam turbine.

MR. EDWIN YAWGER (Pittsburg, Pa.): I regret that Mr. Hodgkinson, who has been connected with the building of the Westinghouse turbine, is not present to say what might be said regarding the Westinghouse turbine. In listening to Professor Robb's paper yesterday I noticed that he brought out one feature in regard to the space occupied by steam turbines. I have looked over many of the actual plans made for turbine installation, and find that the least possible space into which a turbine can be put has been actually expanded in practice, so the area that is actually used is probably twice as much as would be really necessary with the utmost contraction. Of course that is a problem that has to be studied individually, like all other problems in a power-plant design. It has been suggested that the surface condenser could be made a part of the foundation of the turbine. That is entirely possible, on account of the absence of vibration and shock, and I think that Mr. Parsons is actually building some turbines with the condenser as a part of the foundation. In the Westinghouse turbine our usual practice is to make a sort of saw-horse of the turbine foundation and put the condenser and auxiliary pumps and other apparatus underneath. This answers somewhat the same end as placing the condenser right in the foundation. The objection to making it a part of the foundation casting arises from the fact that it would necessitate the turbine manufacturer being also the condenser manufacturer, and that it might possibly restrict the accessibility of the condenser.

Another interesting point has been brought out in connection with steam turbines, and that is the possibility the turbine permits of making very thorough tests at the manufacturer's shop before the machine is shipped. I do not suppose any one ever dreamed of building very large Corliss engines and equipping an engine-room to test such engines thoroughly under commercial conditions. The turbine occupies so little space, and can be set on temporary foundations so conveniently, that it furnishes an opportunity for actual shop tests, which will probably not only lead to a better understanding between manufacturers and purchasers, but will also lead to contributions to science that have never been obtained in an experimental laboratory. The equipment of the Westinghouse Machine Company's shops for this purpose is probably as extensive as anything that has yet been thought of. The testing-room consists of foundations that are capable of receiving turbines from the smallest size up to the very largest. It is possible to place three or four 5000-kw turbines on testing foundations at the same time and to test them one after another, so that the testing operation can be gone through very promptly. The Westinghouse Machine Company has two surface condensers of large capacity, with dry vacuum pumps, and also an independent superheater, which are all a part of the testing equipment. It has been the practice thus far to test thoroughly every turbine built, not only at full load, but at smaller loads, down to one-quarter or one-fifth. Up to the present time there have been some 500 actual tests made on turbines, and some very interesting hitherto mooted questions have had light thrown upon them.

MR. GEORGE S. CARSON (Iowa City, Ia.): There is a marked difference in the efficiency of the turbine when operating under a vacuum of 20 inches and a vacuum of 28 inches. I could not figure it out myself, and I should like a little information on the subject. I should also like to know what vacuum could be obtained by using a cooling tower in connection with the condenser.

MR. EMMET: The curve of the expanding steam is the hyperbola which is prolonged to an asymptote, this asymptote being the line of zero absolute pressure. The cut-off point in the largest condensing engines is not below 15 inches of vacuum. The area traced by engine indicator leaves out altogether a very large extension of volume beyond this pressure. The turbine uses the energy represented by the area in this long point near the asymptote, and its advantage over the steam engine is largely owing to the fact that this additional energy is available. Increased vacuum greatly increases the energy available for the turbine, whereas in the steam engine it simply causes such increase in the area of the indicator card as is afforded by a diminished back pressure.

PROFESSOR CLIFFORD: I have no doubt that Mr. Emmet has in mind the approximate figures for the steam engine run with sulphurous acid on a secondary cycle, which is at present being investigated by Professor Josse in Berlin. My impression is that the steam economy of the ordinary reciprocating engine, with such a secondary cycle, is very nearly as good, if not quite as good, as that which has been stated for the steam turbine. Of course the matter is in an experimental stage at the present time, and has not been tried with large engines. I presume, therefore, the steam turbine would have an advantage over such an equipment; but it seems to me that for a large number of existing plants, using the reciprocating engine, this attachment may possibly be a competitor with the turbine. There are one or two things I should like to ask in connection with the Curtis turbine: What differences are there as to the number of stages, the form of buckets, the shape of nozzle, on turbines intended to be run at different degrees of vacuum? What is the clearance, and also what is the pressure at which the oil is pumped into the step bearing for a 5000-kw unit?

MR. EMMET: I am not familiar with the actual possibilities of the SO_2 attachment to an engine. The use of such substances is undoubtedly of theoretical benefit, and will undoubtedly be continued. It is probably of less benefit with the turbine, for the reason that we can use higher degrees of expansion.

The turbine built for a high vacuum would probably do better with a less degree of vacuum than it would do if it had been built originally for that less degree of vacuum. We might simplify the machine, and reduce the depth of the buckets for low vacuum, but we should gain nothing in economy. We make all machines for a high degree of vacuum.

The clearance is somewhat dependent on the diameter and size of the turbine. We are running about three-hundredths of an inch on our smaller turbines in a vertical direction, and about five-hundredths of an inch on our largest turbines. We find this to be ample. We should gain practically nothing by diminishing it and lose little by slightly increasing it. One of the objects of building the turbine in a vertical position is to make it short. To carry it in a horizontal position would be difficult, and would necessitate the introduction of other bearings. By getting it short the expansion is unimportant, and it does not affect the relative position of the parts. We get a perfectly symmetrical structure, and can run with small clearances. Our original object was to take care of the heavy weights of large machines in a compact place, and the simplicity of the arrangement led to its adoption in other sizes. The pressure in the step bearing is governed by size; 300 pounds per square inch in the smallest turbine, 500-kw, and about 1,100 pounds in the large machines, such as have been built for the Chicago Edison Company. This pressure bearing has been criticized on account of its novelty, but in point of fact it is one of the most satisfactory features of the machine. All turbines must have forced lubrication. Horizontal bearings will destroy themselves if forced lubrication fails, while the vertical bearing is of simple cast-iron blocks and there is little loss if the oil fails. It cuts the surface a little, but our experience has been that by running again they will wear themselves smooth and go on filling their functions. It is easy to make arrangements by which oil lubrication will not fail. We use accumulators, suitably arranged, which are perfectly automatic, and never give any trouble.

MR. GILLE: I would ask what means are provided for ventilating the generators. I understand the generator is direct-coupled to the engine.

MR. EMMET: That is not a point of difficulty. Our steam is expanded down to atmospheric pressure before it enters the shell of the turbine, consequently the upper portion of the turbine is at the boiling point, or the atmospheric temperature of steam. The generator is some distance above the turbine. The whole top of the turbine is of small area, and it can be covered with heavy lagging to any depth desirable. In point of fact, the Chicago machine has been run with steam at a degree of saturation that was equivalent in heating to overload condition of running, and the temperature is satisfactory. There is vigorous ventilation in a rapidly moving machine of this kind, and we have no trouble at all. We lag the top of the turbine and keep the heat away from the generator as much as possible.

MR. M. W. HANKS (Pittsburg, Pa.): I ask if it is practicable to run a high-speed machine on board ship. Does the gyroscopic action have any effect on the turbine?

Mr. Emmet : There have been many turbines of very high speed run successfully on board ship, and I do not think the gyroscopic action has been a source of trouble, although theoretically there is a possibility that it will be. For the Curtis turbine it would be relatively less, because the rotator speed of the turbine is relatively less. It is a relatively slow-speed turbine, of comparatively small weight. In the case of the one boat that has been equipped with the Curtis turbine, there is no trouble in a sea-way through gyroscopic action. It runs at about 650 revolutions per minute.

The President : If there is no further discussion on the turbine question, we will take up the paper on "Salt as a By-Product," by Mr. Alex Dow, of Detroit.

Mr. Dow read the following paper:

SALT AS A BY-PRODUCT

First—This economic age prescribes that, for the continuing commercial success of any business, that business shall be conducted without waste. The management which fails to realize all its possibilities of thrift invites competition that will undersell its market; and this competition, continuing to make lower prices, will ultimately occupy the market to the exclusion of the wasteful producer.

Second—Not only by the adoption of economical processes of manufacture, but by the utilization of all by-products, must the manufacturer of to-day keep down his production cost. In some cases he has apparently the choice between economical manufacture of his chief product without a by-product, and a less economical process which leaves as residue a valuable by-product. A correct choice between these two alternatives requires commercial instinct as well as technical knowledge.

Third—Our friends, the gas companies, have long ago let the public know that their profits are in their by-products. Many of them have modified their gas-producing processes toward lower efficiency in order to increase the value of the by-products. Our other friend, The Standard Oil Company, is somewhat secretive. Nevertheless, we know that the commercial success of that corporation has to no little extent resulted from the utilization of all the contents of the crude oil, whereof in the beginning only illuminating oil was marketed.

Fourth—In our business—the production and sale of electric light and power—our greatest waste has been time—18 or 20 hours out of each 24. We have had, and still have, at best only work enough fully to employ our investment 20 to 25 per cent of the time. Our interest, insurance and depreciation—and our taxes—accumulate during every one of the 8,760 hours of the year. No improved efficiency of generation, no reduction of the losses in distribution, can possibly help us so much as would the discovery of profitable work to which our investment might be set during its hours of idleness. This is not a new theory; it is a long-established and well-recognized condition, and the suggested ameliorations of the condition have been very many.

Fifth—This paper presents the latest of these suggestions, as adopted by the Detroit Edison Company, to wit: the combination with the electric light and power industry of the manufacture of common salt by the evaporation of saturated brine. Obviously, this combination can be made only within well-defined geographical limits. The first requisite is the existence of a sufficient deposit of salt. The greatest store of salt is in the water of the oceans, which contains approximately three per cent by weight of sodium-chloride. To recover this percentage involves the evaporation of 97 per cent of water; which is unprofitable excepting in a limited way, and in warm climates where the sun furnishes the requisite heat. In the United States salt is produced from four principal deposits of rock salt, located as follows:

1. In western New York.
2. In Ohio and Michigan, running from southeastern Ohio northwest through Cleveland; under Lake Erie to Detroit and across the state of Michigan to Lake Michigan at Manistee and Ludington.

3. In south central Kansas.

4. Louisiana.

A limited amount of salt is obtained by mining; running shafts and tunnels directly into the rock salt. There is an excellent demand for this class of salt, which, taken with the cost of production, maintains it at a good price. The more common method, and the method that is used exclusively in the Ohio and Michigan field, is to pump water down to the salt vein, where it dissolves about one pound of salt to each three pounds of water, forming a .25-per-cent brine; this brine, returned by the pressure of the pumps through a separate pipe, is evaporated in open vats or vacuum pans by contact with steam pipes or steam jackets. The building, equipped with vats (called grainers) and vacuum pans, together with the pumps and other machinery required, is in common parlance called a salt block.

Sixth—It is customary to use exhaust steam, when such is available, to heat the brine. This practice has led to the combination with the production of salt of other industries using steam power. In the state of Michigan the most frequent combination with the salt block is a saw-mill, this particular combination being so common that it is almost standard. A saw-mill raises steam by burning its own refuse strips and sawdust; that is to say, fuel is produced in sufficient and sometimes in excessive quantities by the operations of the mill. Old lumbermen said, therefore, that their fuel cost them nothing, and when they, moreover, utilized their exhaust steam in a salt block the commercial result was exceedingly good, and many Michigan fortunes have been earned thereby. These saw-mill salt blocks have had possession of the salt market of the upper lakes for years, and they virtually still control it.

Seventh—In more than one instance an electric-light plant has been operated in combination with a salt block and saw-mill. I could name a dozen such electric-light plants in the state of Michigan. The electric-lighting load comes on at dark, when many saw-mills shut down either partly or altogether. Salt evaporation is preferably, though not necessarily, a continuous process, and the addition of the electric-lighting load is a step toward continuity.

Eighth—The pine, which was the beginning and the strength of the Michigan lumber industry, has nearly disappeared, and with it will go the control of this salt market by the Michigan salt blocks. At Manistee, and in that vicinity, the supply of pine still holds out and the saw-mills and salt blocks are as busy as ever; but on the east shore of the state the pine has been worked out, and the original combination is there no longer possible. Around Detroit, where the greatest salt beds in Michigan have been explored and developed within the last 10 years, there is no pine nor available lumber of any kind, and salt is produced only with fuel bought and burned expressly for the purpose. This leaves but a narrow margin of profit, and if it were not for the lower cost of distribution the industry in the vicinity of Detroit could not exist in competition with that at Manistee. The cost of distribution is a controlling element in the salt business. The material is heavy, and the freight from the salt block to the point of use is frequently greater than the first cost of the salt. In this respect salt and coal are on a similar basis. Each salt field, like each coal field, has a certain area which is its natural area of distribution, and beyond which it comes into competition with the product of some other district. Special qualities of coal, such as the anthracite coal of Pennsylvania, are shipped for special purposes all over the United States; similarly, table salt and other special grades are shipped all over the country; but bulk salt, such as is used by packing houses and in manufacturing and chemical processes, has a well-defined radius of distribution from each producing district. Low first cost will, in some cases, offset high freight rates; and special freight rates (which are not unknown to the salt industry) will extend the radius of some producer who is favored with the same; but these are exceptions not affecting the general rule.

Ninth—The Detroit salt bed is worked to a very great extent by companies producing the salt products—the alkalies—carbonate of soda, soda ash, etc. The Solvay Process Company, whose main works are at Syracuse, N. Y., has established works at Detroit, which were the first on a large scale in that district. Other makers of salt products have followed the lead of the Solvay Company until the alkali industry has become one of the most important in Michigan. These chemicals have a very much wider radius of distribution than has common salt, and the immense salt beds at Detroit, in combination with good water, cheap coal and lime-stone, and excellent lake and rail transportation facilities, now give Detroit an advantage that it is likely to retain for many years.

Tenth—As I have already said, it is not new to turn the exhaust steam of an electric-light plant into a salt block. What is new about the Detroit proposition is the recognition of the possible reaction of salt production on the electric light and power business. Economically, it would be just as profitless to operate a salt block during the few hours when an ordinary electric-light system would give it a liberal supply of steam as it is to operate that same electric system only during those hours. To work the electric-light investment to good purpose, requires a better load factor than is usually obtained. To work the investment in a salt block to the best purpose, requires continuous operation. A salt block that takes and utilizes the exhaust steam of a lighting plant at its peak load and is idle or using live steam at times when the electric-light plant is lightly loaded, can not be made to pay. But if a continuous load can be obtained for the electric-light machinery, a continuous and profitable operation can be assured to the salt block. The converse is true; namely, that if all the exhaust steam of the continuously running electric plant is profitably used in the salt block, the reduced or extinguished cost of fuel will make the electric-lighting business profitable. To obtain this very desirable state of affairs it is necessary to find the continuous electric load. The use of electric light has physical limitations. People are not going to turn on lights in the daytime merely to be kind to the electric-light companies. Differential rates will improve your electric-light daily load curve and will bring you business that would otherwise go to kerosene or gas; but, after all, it is essentially a night business—I may even say an evening business, because all-night lighting is a comparatively small portion of the maximum demand. Electric power is a different proposition. Industries that use power 24 hours a day have always existed, and their number is increasing. To these must be added the industries—mostly chemical—that use electricity for heating or for electrolysis. To these may yet be added—if the inducements are sufficient—industries that now use power only eight or ten hours per day, but that, if power be cheap enough, can profitably work a night shift or even establish continuous 24-hour operation.

Eleventh—The possibility of creating a manufacturing district of such industries has been demonstrated at Niagara Falls. Cheap power, cheap and convenient transportation, and cheap land, are the essentials. With these it is desirable to have an existing population which takes kindly to factory work. All the conditions except the cheap power are existent in Detroit, and our proposition is to furnish the missing essential. We believe that among the industries already established in the city of Detroit, and among those which can be brought to locate in the city or in its vicinity, we can find such a demand for our electric product as will enable us to operate with a good load factor 24 hours a day and 365 days a year. Under these conditions the exhaust steam from our engines can be profitably utilized in the evaporation of brine—that is to say, in the production of salt; the sale of the salt will reduce or extinguish our cost for fuel; and it will be practicable for us to sell electric energy—the fuel cost being reduced or extinguished—at such figures as will secure the stability of our economic combination.

Twelfth—You will observe that I do not say that salt as a by-product will in itself make the difference between profitless and profitable operation. It is good to utilize your exhaust steam; but because you don't utilize it you are not necessarily throwing away your dividends, nor sending them out of the chimney, according to advertisement. If the proposition merely afforded a use for our exhaust we should run condensing. Indeed, we are providing condensers for use under certain conditions, of which more hereafter. What we see in the plan, and what I am trying to show to you, is the possibility of utilizing the idle hours of our electric investment. The business we expect to get during these idle hours can only be obtained at low prices—virtually at cost of production. The profit lies in the fact that the salt business will reduce or extinguish the fuel cost. Wherefore it is hard to say whether during these hours of sometime idleness the electric supply will be our business and the salt will be our by-product, or whether we shall be truly in the salt business with electricity as the side-show.

Thirteenth—About those condensers. We don't expect to do away with the peak of our electric load. That will be always with us, like the poor and the tax collector. We shall have to put up with it, more or less, as with them. But we can provide for the peak in either of two ways. We can have spare engines and boilers, continue to run non-condensing, and crowd the salt block to use the excess steam, or turn it into the atmosphere. Or we can shut down part or all of the salt block for the hour or two and run some or all of our engines condensing. The latter plan suits us best, and requires less investment. It does not pay to crowd a salt block—it affects the quality of the salt. And it does not hurt to shut it down, except to the extent of the loss due to the investment being idle. That latter loss is less if the block is idle during the few hours of winter peak and the condensers idle the rest of the year, than if spare engines and boilers, and land and building to accommodate them, were idle all the year and busy only during the peak.

Fourteenth—I have just indicated one aspect in which the salt block as a user of exhaust steam is preferable to a steam-heating system. I can shut down my block the week before Christmas and no one will complain. The men who work in the block will probably even be happy to take a holiday just then. But please shut your eyes and imagine the lovely row there would be if I undertook to shut off my steam-heat distribution that same week. Then I can run my salt block all summer and ship my summer product up lake till navigation closes. I wish I could sell steam heat all summer. Also, the salt block will use what steam I give it at the times I give it, and will not want to be specially warmed up at six o'clock each winter morning; neither to have the heat turned on again for a Fourth of July celebration that has failed to make seasonable arrangements with the weather bureau.

Fifteenth—There are many interesting engineering problems connected with our proposed combination of industries. For instance, the question of the economical limit of the back pressure on our engines (which are to be turbines), is exceedingly complex. We can make that pressure just about what we please by proper design of the salt pans; but the first cost of the pans, the rate at which they can be worked, and the quality of the salt produced, are all varied by variation of the back pressure. Again, although we run non-condensing, we shall have an ample supply of distilled water for our boiler feed in return from the pans; but the economical temperature of this feed water is a matter of discussion. Still more interesting is the question of how to utilize the waste heat of flue gases—whether in heating brine or in heating feed water.

Sixteenth—These matters, although interesting, are secondary. Moreover, this paper is already long enough. Like the cowboy who was chased by Indians through the Bad Lands, I have hit only the high places of the trail. If you want to hear from me of what lies between, I must make another trip at another time. When that time comes I shall know more about the subject.

THE PRESIDENT: If there is no discussion on Mr. Dow's paper, we will pass on to the next number on the programme.

I want to say with regard to the gentleman who will present the next paper, that he has been kind enough to come all the way from Boston to attend this convention, and he has also been kind enough to take part in the various discussions we have had, and I know that we shall much appreciate anything Professor Clifford may tell us. I have the pleasure of calling upon Professor Clifford, associate professor of electrical engineering of the Massachusetts Institute of Technology, who will address us on "Some Fundamentals of Photometry."

SOME FUNDAMENTALS OF PHOTOMETRY

Mr. President and Gentlemen of the National Electric Light Association:

To the electrical engineer the problems of illumination, both exterior and interior, are to-day taking on a much increased importance and interest. The science of photometry is fundamental to these broad questions of illumination, and it is unfortunate that the scientific method, which has done so much during the past twenty-five years for the advancement of engineering in general, should in mätters photometric be conspicuous rather by its absence.

The careful study of methods and apparatus applicable to any given problem, and the exact statement of the conditions under which the work is to be carried out, which give to much of the engineering of to-day a high value in the field of scientific research, seem in measurements of the illuminating power of the various light sources not to have the place that they deserve. Much of this is perhaps to be accounted for by the fact that photometry is intimately connected with physiological questions, which introduce more or less uncertainty in the results. Then, too, until within a few years the very unsatisfactory character of the standards of light has made photometry a somewhat inexact science.

In speaking to you on "Some Fundamentals of Photometry," I intend to refer briefly to a few points that seem to me not to have received up to this time the emphasis they merit. In attacking any photometric problem, we should first select the type of photometer that will give the greatest precision for the special line of investigation we are to pursue. It is to be remarked that the various photometers in ordinary use do not by any means give the same light ratio when comparing two given sources under precisely the same conditions. As a basis, then, for estimating the accuracy of different photometers, the ultimate method would be a determination of the light energy of two given sources by means of the spectro-photometer, and a comparison of their total energy ratio with the ratio of illumination as determined by the Bunsen, the Lummer-Brodhun, or whatever photometer it is desired to use. This would necessitate an extended investigation, with a large number of light sources. It has seemed to me, therefore, a fair basis of comparison to adopt the average deviation of a considerable number of settings, taken under the same conditions with the different instruments, as a measure of the relative accuracy of these different photometers. In speaking, therefore, of the superiority of one type over others for any particular piece of work, I mean to indicate that the average deviation of the series of readings for this instrument is least, the readings being taken under the same conditions for all the photometers to be compared.

It has become the custom to use the Lummer-Brodhun type of photometer for all kinds of work, irrespective of its character. To my mind there are serious objections to the use of this instrument, especially where the lights to be compared are of different colors, such, for example, as an arc and an incandescent light. In the hands of the skilled observer, and where the lights to be compared are of the same hue, there is no question that the Lummer-Brodhun photometer is to be preferred to any other type. To be sure, there is the objection of using a single eye in the observations, as this causes somewhat rapid fatigue and consequent decrease in the accuracy of setting. On the other hand, there is the advantage that certain sources of error that arise in connection with viewing opposite sides of a photometer screen, one with each eye, are eliminated. The Bunsen photometer possesses for arc-light photometry, however, distinct advantages over the Lummer-Brodhun: that is, if the arc is compared with an incandescent light standard. From results that have been obtained by many observers at the Massachusetts Institute of Technology during the last six years, there is no doubt that the average deviation of a series of readings taken with the Bunsen is less than with the Lummer-Brodhun, and the precision of setting is longer maintained. Of course, care should be taken that the distance from the observer to the Bunsen screen is so great that the images of both sides of it are well seen by each of the observer's eyes. Otherwise, errors of considerable magnitude may arise, due to the unequal sensitiveness of the two eyes. A photometric study of lights of different color should always be preceded, for work of the highest accuracy, by an investigation of the various types of photometers, to ascertain which gives the greatest precision in the particular case in hand. Thus the instrument which is most satisfactory for work with lights of a bluish tinge may be far less precise in the measurement of lights of a reddish hue. It is just this superiority in work with lights of a bluish tinge that gives the Bunsen its advantage for arc-light photometry.

In this connection, also, I want to urge the claims of the Flicker photometer, which for some reason seems to be very little used. For work with colored lights, and lights of different color more particularly, it is decidedly superior to either the Bunsen or the Lummer-Brodhun. Here, again, the careful investigator will determine the speed of flicker that gives the greatest precision. My own investigations have shown that this speed is different for different colors, and varies with the observer, as would be naturally expected. The Flicker photometer is easily constructed and simple in its manipulation, possessing an accuracy for color work in general greater than that of any other type of instrument.

The Joly diffusion photometer, and the Krüss prism type of Bunsen, whose use has been more or less advocated, do not seem to me to possess any advantages, or increased precision calling for their substitution in place of the better-known types.

I may illustrate the necessity for an exact statement of the conditions under which photometric work is carried on, by the results of certain tests on the relation of candle-power to voltage for the Nernst lamp.

In Figure 1 is given the plot of such a relation, the test being carried on as follows: Starting with a given voltage and corresponding candle-power, which we will call for both "normal," the voltage is altered by steps of twelve volts each on the half minute, and a reading of the corresponding candle-power taken on the even minute. That is, the voltage is altered every minute, and the candle-power taken every minute, the reading of the illumination being in every instance one-half minute later than the corresponding change of voltage. The results at once suggest the well-known hysteresis loop for magnetic materials, and I would especially emphasize the marked difference in voltage, corresponding to a given candle-power on the ascending and descending sides of this photometric loop, for voltages above the normal. Curiously enough, at voltages below the normal the ascending and descending parts of the curve differ very little.

Figure 2 gives the results of a second and similar test on the same lamp, a single-glower Nernst, and shows that the effect in the first case is certainly not accidental.

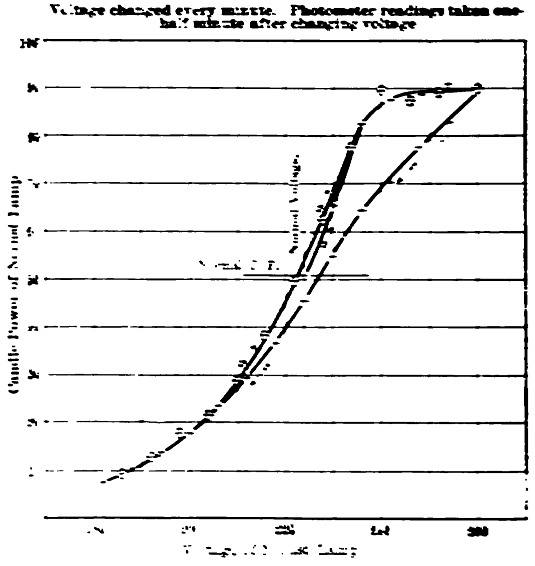


Fig. 2

The curve of relationship of candle-power and voltage is evidently different according as the observations are made with increasing or decreasing values of the electromotive force applied at the lamp terminals. This difference amounts at candle-power 80 (see Figure 2) to 16 volts, the voltage being 235 on the ascending and 251 on the descending side of the curve.

It is interesting to note that after having traversed the loop once, subsequent changes of voltage made according to the same law cause the same loop to be again and again gone over. It seems to me probable that the lack of agreement in the results of different observers is to be accounted for by the different manner of taking the readings and making the changes in voltage.

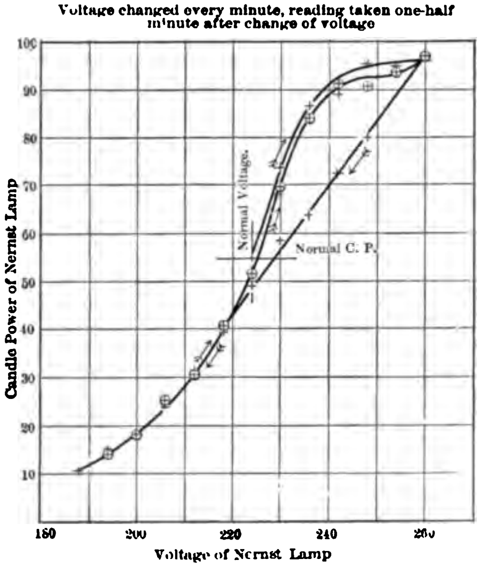
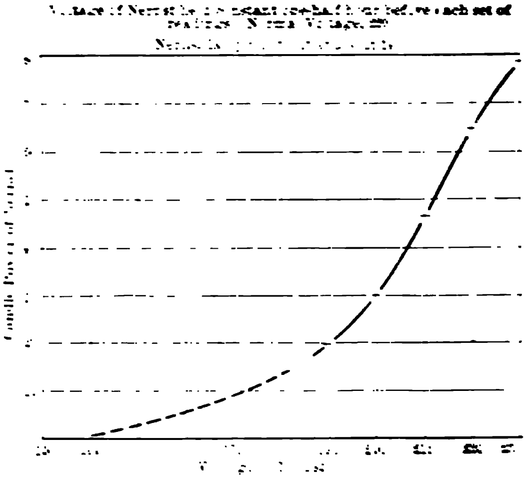


FIG. 2

The time element also enters most markedly into this voltage—candle-power relation. Thus, compare Figure 3, in which 10-volt steps are taken and one-half hour allowed to elapse before the corresponding candle-power determination is made, with Figures 1 and 2. In Figure 3 it is rather interesting to observe that the prolongation of the curve to the point of zero candle-power shows that this should occur at 140 volts. On lowering the voltage it was found that, as nearly as could be judged, the lamp ceased to glow at just about 140 volts.

With a single-glower, 225-volt Nernst lamp, the voltage was dropped 10 volts, held constant at this decreased value for one minute, and then restored to its normal value of 225 volts. At this point photometric readings were begun, the standard light being



an incandescent maintained at constant voltage, and the relation of candle-power to time is shown in Figure 2. It will be seen by the curve that it is a matter of seven or eight minutes after the voltage has been restored to its normal value before the illumination returns to its normal value. Smaller changes in voltage maintained for shorter times show similar effects, naturally of lesser magnitude. The sensitiveness of the Nernst lamp to change in voltage is of course well known, but my reference to it is rather as indicating the necessity, from the photometric standpoint, of clearly indicating all the conditions under which given observations are taken. The change in the case just mentioned, of 16 per cent in illumination due to a temporary drop in voltage of five per cent, is the special matter to be emphasized, together with the time taken for the lamp to return to its normal candle-power after the voltage has been again adjusted to its standard value. Changes in voltage of five per cent are of course somewhat excessive, but the character of the effect still remains, though of reduced magnitude, for any lesser variation in voltage.

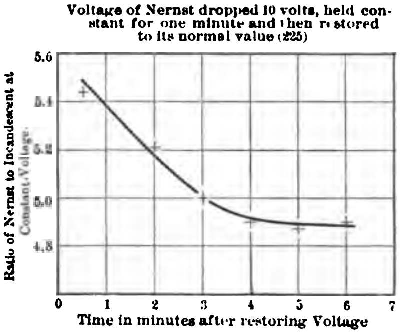


FIG. 4

In Figure 5 is given the relation of candle-power to time after lighting for a single-glower Nernst, maintained at a constant potential at the terminals of 225 volts. Immediately following the lighting of the lamp the drop in candle-power is very rapid, amounting in the first five minutes to 50 per cent of the final value. The total variation in this particular case is about 60 per cent of the final value, and the illumination does not become constant until nearly an hour after the lamp is lighted. It is absolutely essential, therefore, if candle-power determinations of the single-glower Nernst are to mean anything, that at least this time shall elapse after the lighting of the lamp before photometric observations are begun.

I have earlier referred to the effect of certain physiological phenomena upon the accuracy of photometric work, and the special point to which I wish now to direct attention is the influence of the so-called Purkinje effect, which, briefly stated, is this:

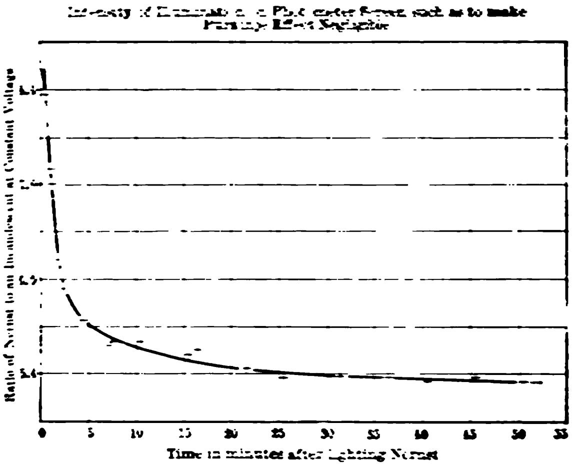


Fig. 5

If a red and a blue light be placed a certain distance apart, let us say 100 inches, and the ratio of their intensities be determined, we may suppose, for the sake of illustration, that the ratio is unity; in other words, the two lights are of equal intensity. Let them now be placed 125 inches apart, in which case, of course, the photometer disc is less strongly illuminated than at first, and it will be found that the measurement gives the blue a greater intensity than the red. Whereas if the lights are now moved nearer together—to a distance, say, of 75 inches—in which case the illumination of the photometer disc is greater than in the first instance, and the ratio of intensities once again determined, the red will be found to have a greater intensity than the blue. That is, broadly speaking, in faint illumination blues are more prominent, whereas in strong illumination, the reds and yellows are accentuated. This effect is not confined to red, yellow and blue lights, but is evident in sources having merely a tinge of one or another of these colors. This phenomenon was noted by Purkinje as far back as 1820, and its influence in photometry is distinctly recognized, though the manner in which its effect is allowed for by different observers is, I think, open to serious question.

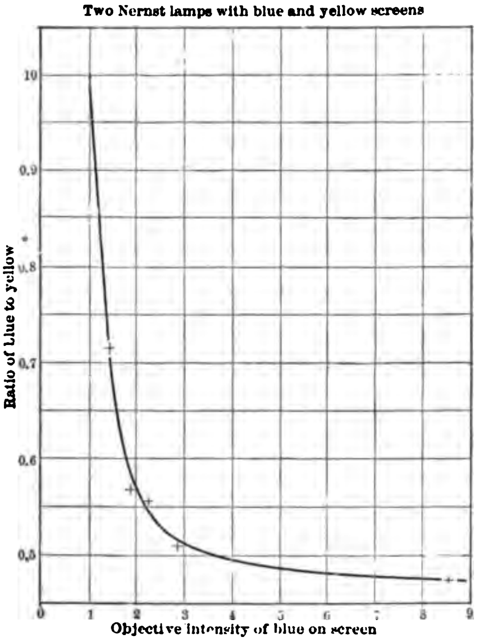


Fig. 6

First let me illustrate the influence of the Purkinje effect in some tests carried out with Nernst and incandescent lamps. Figure 6 shows the relative intensity of two single-glower Nernst lamps, placed on the same circuit, with constant potential maintained at their terminals. The distance between the lamps was decreased in moderate steps, thus giving an increased illumination of the photometer disc. The lights were screened, the one with a bluish, the other with a yellowish, screen, so that the effect on looking at the Bunsen disc was not very different from that produced by an open-arc and an incandescent standard. After a setting had been made with the color screens in position—these screens, by the way, being carried in the photometer box—they were removed, and the lights calibrated against each other. This was repeated for each distance apart of the two lamps. Throughout the test the ratio of intensities of the unscreened lights remained constant. It will be noticed from the plot, however, that with low illumination of the photometer disc the ratio of blue to yellow is much greater than when the disc is brightly illuminated, as it is with the two lamps close together. Calling the ratio of the blue to the yellow light unity when the lights are farthest apart, the illumination of the disc in this case being assumed arbitrarily as 1, we find that this ratio becomes 0.47 when the lights are at their minimum distance apart, and the illumination of the photometer disc is 9; that is, nine times as great as it was in the first position of the two lamps. By merely altering the illumination of the photometer screen—in this instance accomplished by varying the distance between the lights—the measured intensity ratio of the two given lights may be made to vary by over 50 per cent, assuming the standard ratio to be that obtained for the least intense illumination of the disc, and by over 100 per cent, if the standard ratio be assumed as that corresponding to the most intense illumination of the photometer disc.

In the illustration just given of the effect of this phenomenon, the difference in color of the two sources is well marked. Let us next consider two lights for which this difference is but slight. Two incandescent lamps were adjusted, the one for five per cent above, the other for seven per cent below, the rated voltage, thus giving one a whiter light, the other a redder light, than would normally result with these lamps. The ratio of the intensities for different illuminations of the photometer disc, that is, for different distances between the lamps, is given by the curve in Figure 7. Here, again, we observe a change in intensity ratio from 3.8 to 3.1, approximately, corresponding to a change in the illumination of the disc from 1.3 to 10, although the color difference of the two incandescents being less than with the screened Nernsts, the variation of intensity ratio is of course less.

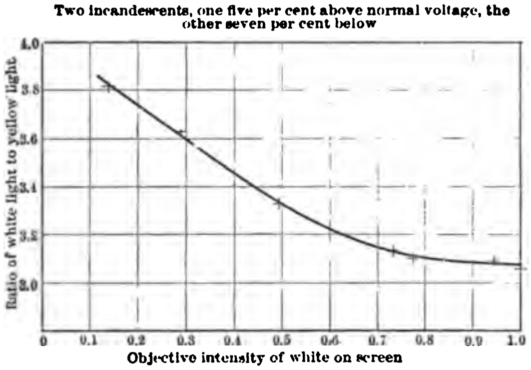


FIG. 7

One more illustration will suffice, and is given in the comparison of a Nernst with an incandescent standard, the change in the illumination of the Bunsen disc being produced as before by varying the distance between the two lamps. In this case, also (see Figure 8), the characteristic change in the ratio of intensities due to the Purkinje effect is clearly indicated. Naturally, the influence of this particular physiological phenomenon is much more marked in arc-light photometry, where the bluish color of the arc against the yellowish tinge of the incandescent standard gives us an ideal combination, so to speak. It is frequently the plan to allow for the Purkinje effect in this case by cutting down the intensity of illumination of the photometer disc, which may be accomplished by the use of sectored discs, absorbing or diffusing media, or a photometer bar of great length. The illumination is reduced to such a point that the ratio of the intensities of the lights to be compared becomes fixed, as shown by a constant reading of the photometer. This, as a reference to Figure 6 will show, is, however, nothing more nor less than accenting the blue light at the expense of the yellow; in other words, making the arc light appear to have a much greater intensity of illumination than

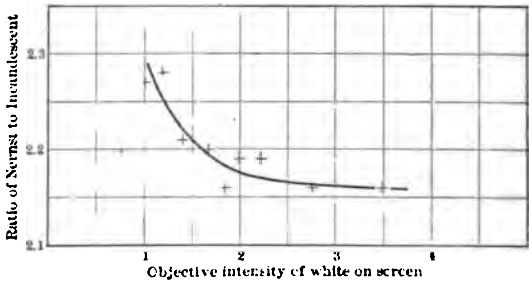


FIG. 8

that to which it is justly entitled. It may be urged, it seems to me, with equal force, that we *increase* the illumination of the disc until the photometer reading becomes constant, in which case, as shown by Figure 6, the ratio of the arc to the incandescent will be less by a very considerable percentage than that obtained in the ordinary way.

The changes in apparent ratio, due to the influence of the Purkinje effect, affect the whole field of arc-light photometry. Questions of distribution curves, the absorption of different media used in the inclosing globes for arc lamps, the relative efficiency of the open and the inclosed arc, will all be influenced by the decision as to the conditions of illumination of the photometer disc under which the tests are made.

Rather than continue the present method of making comparisons under faint illumination for arc-light work, or, as in many cases, letting the comparison be carried out without any definite understanding as to the conditions, it seems to me we ought to decide on a definite illumination at the photometer disc in Hefner meters, under which tests should be made. This illumination should not be one that puts the incandescent light at such a disadvantage in comparison with the arc as that now commonly, not to say generally, adopted. There are other objections that may be urged against the present method from the standpoint of Talbot's law, but with these we need not at this time concern ourselves. Better still, possibly, is the giving up entirely of intensity measurements in determining the efficiency of any luminous scource, replacing these by tests of our power of seeing under the illumination of the particular light in question.

In closing, it is distinctly a pleasure to express my appreciation of the efficient aid that has been given me in the experimental work by Mr. R. R. Lawrence, instructor in electrical engineering in the Massachusetts Institute of Technology.

THE PRESIDENT: Before having discussion of Professor Clifford's paper I think it will be well for us to have the report of the committee for investigating the photometric values of arc lamps, by Professor C. P. Matthews, of Purdue University.

The following is the report of the committee, an abstract of which was read by Professor Matthews:

FOURTH PROGRESS REPORT OF THE COMMITTEE FOR INVESTIGATING THE PHOTOMETRIC VALUES OF ARC LAMPS

Mr. President and Gentlemen of the National Electric Light Association:

Your committee submits herewith its fourth progress report.

As heretofore, the work has been conducted in the photometric and electrical laboratories of Purdue University, to which institution the committee would express its indebtedness. The committee has received, from time to time, requests for measurements made upon sources other than the arc lamp. Realizing the importance of comparative results, the committee has during the past year authorized tests upon several light sources now in common use, these tests to be conducted in the same laboratories and with the same care and rigor that have characterized its previous work. More particularly the sources tested during the past year have been the Nernst lamp, the mantle burner of the Welsbach type and the open gas flame.

The committee would express its obligation to the Nernst Lamp Company, of Pittsburg, for the use of lamps and shades of different types. The other materials used, such as mantles and gas tips, have been purchased from dealers conveniently at hand.

The committee hopes that the data and results in the following pages will be regarded as a fair equivalent for the financial support received, and that the broadened scope of the committee's work, which, it will be noted, is not exactly covered by the title, will meet with a favorable reception.

(Signed) HENRY L. DOHERTY, Chairman.
W. E. GOLDSBOROUGH,
C. P. MATTHEWS, Photometrist.

To the Committee for Investigating the Photometric Values of Arc Lamps:

The material of the following pages may properly be classified as follows:

(I) Tests of the Nernst lamp

(II) Tests of the mantle gas burner

(III) Tests of the naked gas flame

(IV) A consideration of the illumination derived from these sources.

APPARATUS AND UNITS

For the work on gas sources, it has been necessary to equip a special room with a photometer capable of giving, if desired, the mean spherical and mean hemispherical candle-power at one setting, the apparatus being similar to that described in previous reports on the photometry of the arc light. The decision to continue the work of the committee was made somewhat tardily, and the equipment of this room with the necessary photometric apparatus, meters and pressure regulators, has consumed a considerable portion of the available time.

The results in this report are expressed uniformly in candle-power. The values may be reduced to Hefner units by multiplying by the factor 1.14.

PHOTOMETRY OF THE NERNST LAMP

Photometric tests have been conducted with much care on Nernst lamps, of the one, three and six-glower types, equipped with the various globes, shades and heater cases furnished by the manufacturers.

In Figures 1 and 2 the globes, shades and heater cases are well shown, as regards their relative size, contour and density.

Figure 3 shows the different images of the three-glower Nernst lamp as seen from a point near the photometer screen. The effect is precisely that which one would obtain in passing half-way around the lamp in a vertical plane, stopping at 15-degree intervals to view the lamp. The distribution of candle-power is obtained by uncovering, one at a time, the mirrors producing these images, while the mean spherical candle-power is obtained at one photometer setting, if all mirrors

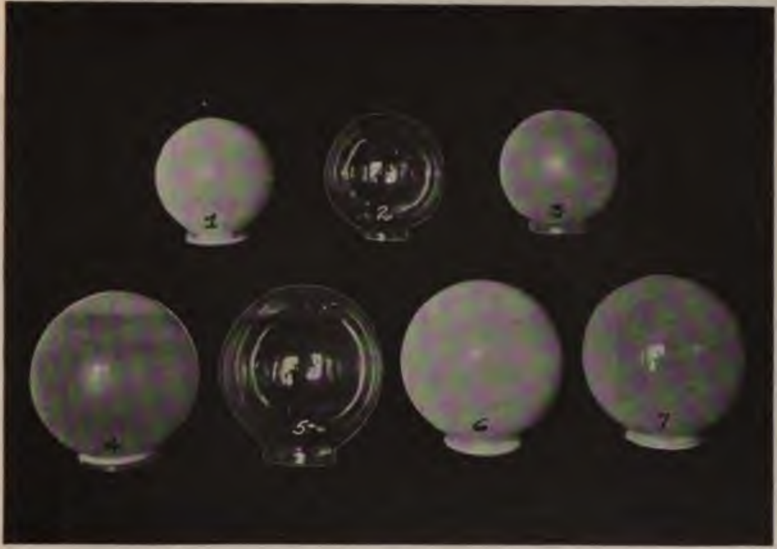


FIG. 1—GLOBES FOR THREE AND SIX-GLOWER NERNST LAMPS

(1) Three-Glower—Pearl Opal. (2) Three-Glower—Clear. (3) Three-Glower—Sand-blasted. (4) Six-Glower—Sand-blasted. (5) Six-Glower—Clear. (6) Six-Glower—Pearl Opal. (7) Six-Glower—Opalescent

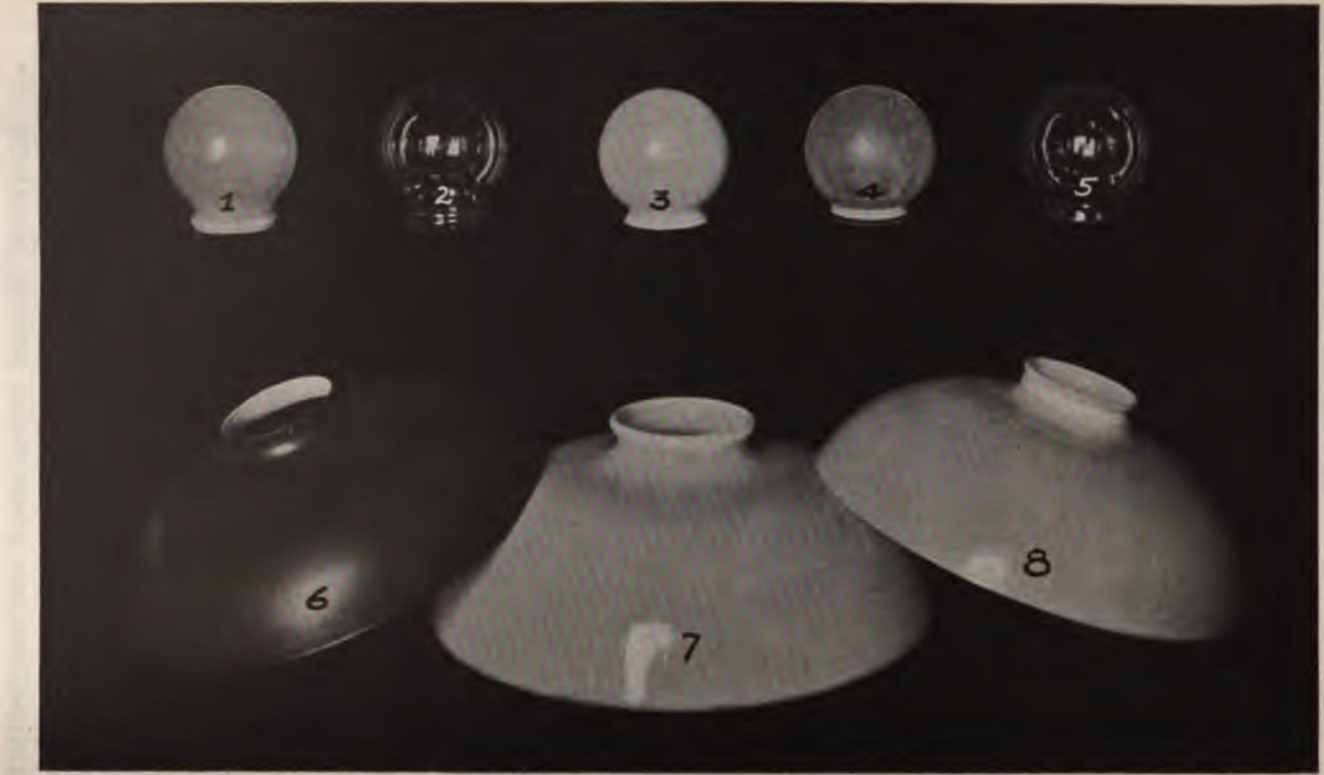


FIG. 2—HEATER CASES AND SHADES FOR NERNST LAMPS

(1) Three and Six-Glower Heater Case—Opalescent. (2) Three and Six-Glower Heater Case—Clear. (3) Single-Glower Globe—Pearl Opal. (4) Single-Glower Globe—Sand-blasted. (5) Single-Glower Globe—Clear (6) Three-Glower Shade—Metal. (7) Six-Glower Shade—Opal. (8) Three-Glower Shade—Opal

are uncovered at one time and the candle-power from each image cut down according to a definite law. Incidentally, these images show the large amount of light thrown downward and the relatively small amount thrown upward in this type of lamp.

In Figure 5 are given six curves showing the variations of candle-power with voltage of six different single-glower Nernst lamps. In making these tests the lamps were burned under normal voltage for 15 minutes, then the voltage was reduced about 10 per cent and a candle-power reading taken at the end of five minutes. At the end of each subsequent five-minute interval the voltage was raised about two per cent, and candle-power readings taken after five minutes burning at the new constant voltage.

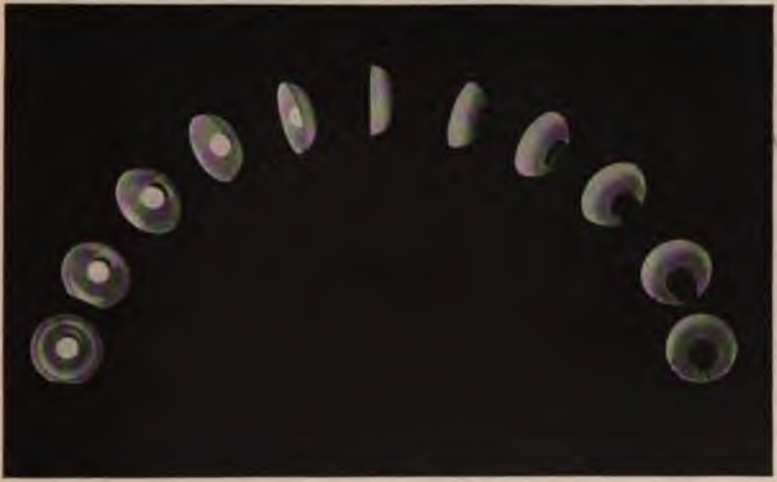


FIG. 3—SHOWING THREE-GLOWER LAMP EQUIPPED WITH OPALESCENT HEATER CASE AND OPAL SHADE ARRANGED FOR VERTICAL DISTRIBUTION

In lamps 1, 3 and 5 the glowers were new and the lamps accordingly gave higher candle-power readings than did lamps 2, 4 and 6, which had been burned approximately 200 hours before they were tested. The Nernst lamp goes through a seasoning

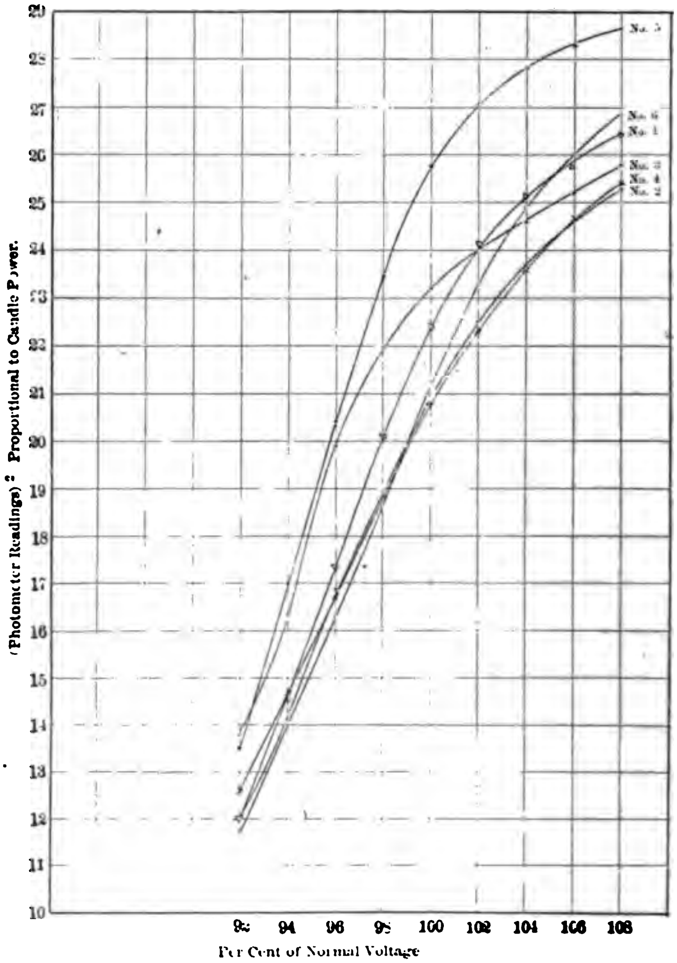


FIG. 5—VARIATION OF INTENSITY OF SIX SINGLE-GLOWER NERNST LAMPS WITH CHANGE IN IMPRESSED VOLTAGE. LAMPS 1, 3 AND 5 WERE NEW, LAMPS 2, 4 AND 6 HAD BEEN BURNED ABOUT 200 HOURS

process in the early part of its life during which its candle-power is reduced. However, the candle-power soon reaches a value below which there is little reduction during the remainder of its life.

The Nernst lamps used in determining the distribution curves that follow were new when tested.

TABLE A

NERNST LAMP

CHANGE IN CANDLE-POWER WITH CHANGE IN VOLTAGE

Per Cent Voltage		Per Cent Candle-power						Average Per Cent Candle-power		Average All
		Lamp No. 1	Lamp No. 2	Lamp No. 3	Lamp No. 4	Lamp No. 5	Lamp No. 6	Lamps Nos. 1, 3, 5	Lamps Nos. 2, 4, 6	
Above	8	18.30	22.00	11.20	22.10	11.25	27.50	13.58	23.90	18.74
	6	15.19	17.10	8.64	18.75	9.70	23.23	10.84	19.69	15.26
	4	12.50	12.82	6.04	13.45	8.15	18.00	8.89	14.76	11.83
	2	7.60	7.13	3.45	7.22	5.04	10.42	5.36	8.26	6.81
Normal										
Below	2	10.28	9.75	5.17	8.65	8.93	11.38	8.13	9.93	9.03
	4	22.75	19.80	14.20	19.25	20.90	22.50	19.28	20.52	19.90
	6	35.25	32.60	29.30	29.30	34.10	33.20	32.88	31.70	32.29
	8	40.50	43.10	40.80	39.40	47.70	44.60	45.00	42.40	43.70

Lamps 1, 3, 5 are new.
Lamps 2, 4, 6 aged approximately 200 hours.

Figure 6 shows the distribution of candle-power from a six-glower lamp in a horizontal plane containing the glowers. It will be seen that the candle-power in this plane varies between wide limits. Normal to the glowers the value is 260 per cent of that parallel to the glowers. This horizontal distribution of candle-power is characteristic of the parallel arrangement of glowers in a horizontal plane. It is interesting to contrast this curve with similar curves obtained from the naked gas flame, the mantle burner and the arc lamp. These last-named sources give candle-power distributions in the horizontal plane that

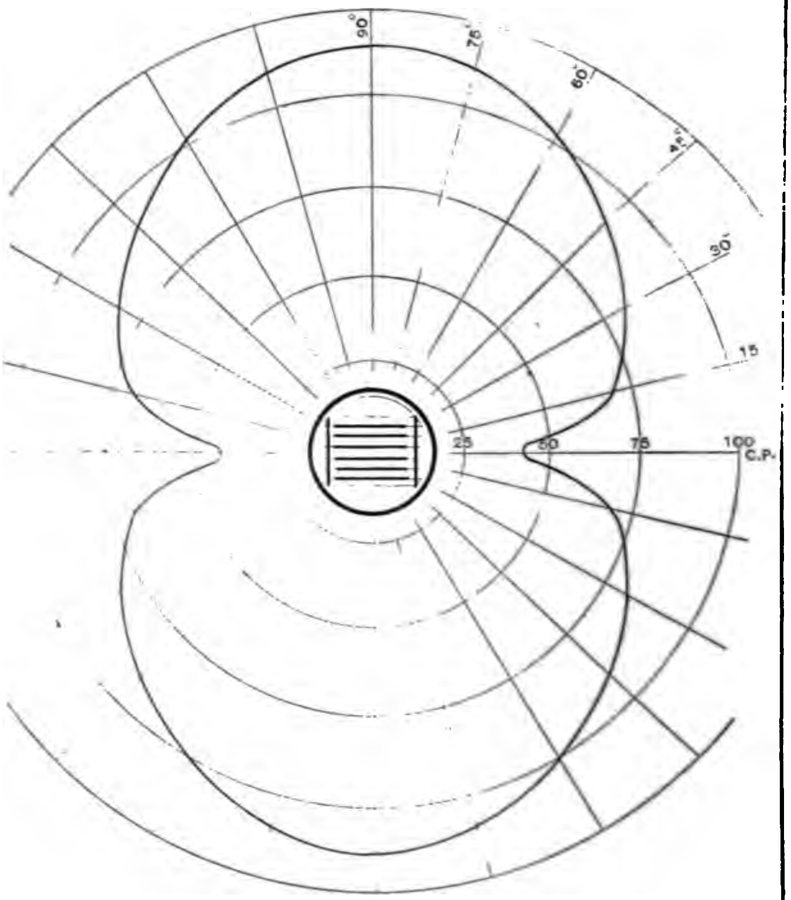


FIG. 6—HORIZONTAL DISTRIBUTION OF CANDLE-POWER ABOUT SIX-GLOWER LAMP EQUIPPED WITH CLEAR GLOBE

are circular, or nearly so. When the Nernst lamp is equipped with a diffusing globe, its horizontal distribution of candle-power is, of course, considerably rounded out.

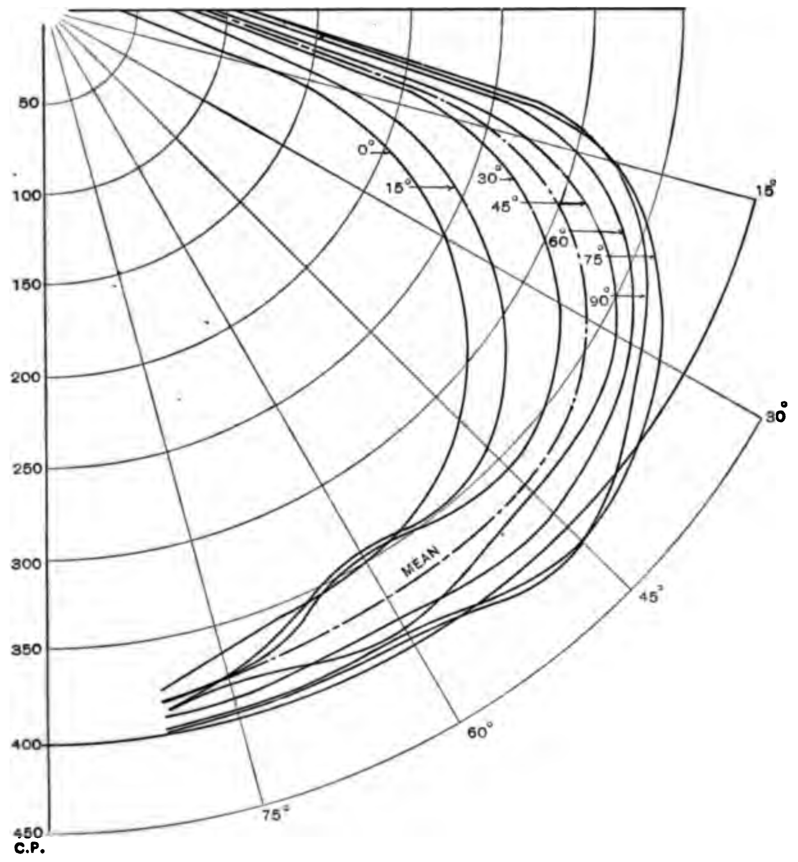


Fig. 7—Distributions of Candle-power in Vertical Planes 15 Degrees Apart for Six-Glower Lamp Equipped with Clear Globe

Similar facts are shown from a consideration of the candle-power distribution in different vertical planes. Thus, in Figure 7, the data for which will be found in Table X, further on in this report, the parallel or "end-on" candle-power curve is seen to be the smallest of all. The candle-power in the vertical plane 15 degrees to the axis of the glowers is somewhat larger, the candle-power in a 30-degree plane still larger, and so on. Because of this unsymmetrical distribution of candle-power, the computation of the mean spherical intensity presents some difficulties not found in the case of the other sources referred to. The difficulties are, in fact, precisely those encountered in spherical measurements on an incandescent lamp. In Table I, the relative errors in the three different methods of computing the mean spherical intensity from candle-power distributions are shown. The methods are: (1) From the mean of six distribution curves in vertical planes 15 degrees apart; (2) From the mean of two distribution curves, namely, parallel and normal to the glowers; (3) From a single distribution curve in a vertical plane 35 degrees to the glowers.

TABLE I

ERRORS IN COMPUTATION OF MEAN SPHERICAL AND MEAN HEMISPHERICAL CANDLE-POWER

Lamp	Mean of Six Curves Every 15° Around Glowers	Mean of Parallel and Normal	35° to Glowers
	———Per Cent Error———		
Six-glower, Clear Globe, Mean Hemispherical	0	−4.3	
Six-glower, Clear Globe, Mean Spherical	0	−4.	
Six-glower, Pearl Opal, Clear Globe, Mean Hemispherical	0	+ .8	−2
Six-glower, Pearl Opal, Clear Globe, Mean Spherical	0	+1.8	−1
Three-glower, Pearl Opal, Clear Globe, Mean Hemispherical	0	+ .5	
Three-glower, Pearl Opal, Clear Globe, Mean Spherical	0	+ .9	

Considering the first method as correct, the errors in the other two methods are as tabulated. The second method seems to yield a result correct to about one per cent when diffusing globes are used, and about four per cent when clear globes are used. It was found that there is no single plane in which a candle-power distribution can be taken and integrated for the mean spherical intensity with correct results for all types of globes and shades. With an integrating photometer, however, the matter becomes simply that of taking five or six photometer settings, the mean of which yields the value sought.

The results of a careful test on a single-glower Nernst lamp are given in Table II and in Figures 8 and 9. This lamp is rated at 220 volts, but it was found that more uniform candle-power measurements could be obtained by operating the lamp at a constant current of .4 ampere through the glower. Under these conditions of operation the voltage will not be exactly 220, but will differ but slightly from that value. The results show that the Nernst lamp equipped as indicated gives maximum candle-power directly beneath the lamp. The specific power consumption with clear globe is 2.31 watts per mean hemispherical candle-power and 4.11 watts per mean spherical candle-power. The great difference in these figures is due to the fact that the Nernst lamp throws the great volume of its light downward. It may be said that for many purposes this distribution of light is very satisfactory, there being sufficient upward light for the purposes of general illumination, while the light thrown downward within an angle of 45 degrees from the vertical is very strong, making a desirable source for the illumination of reading tables, counters, machines, and so forth. A comparison of Figures 8 and 9 brings out the great difference in the distribution of candle-power in the two vertical planes respectively

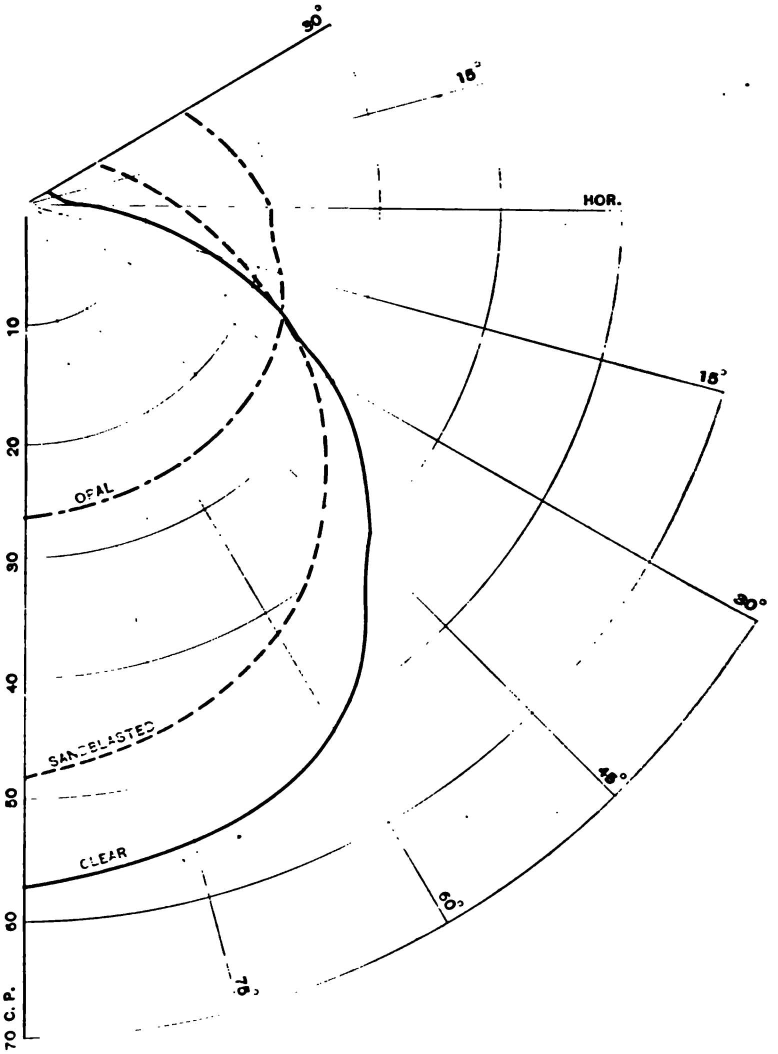


Fig. 8—Distribution of Candle-power from Single-Glower Nernst Lamp, in Vertical Plane Containing the Glower. Globes as Indicated in the Figure

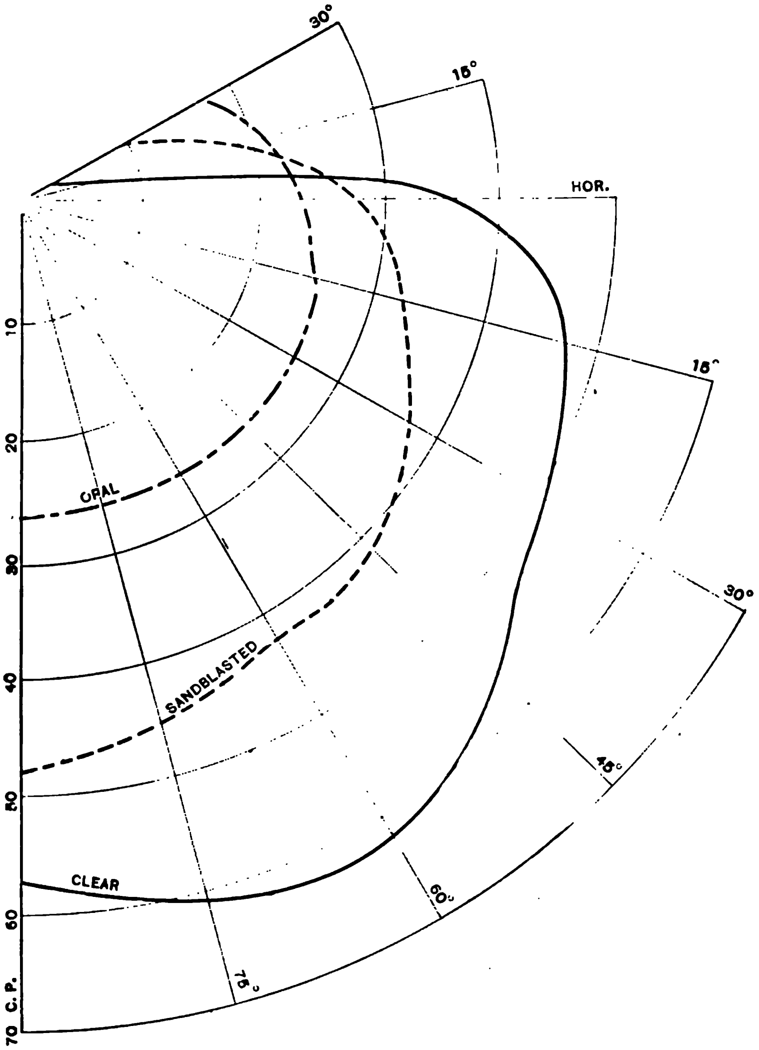


FIG. 9—DISTRIBUTION OF CANDLE-POWER FROM SINGLE-GLOWER NERNST LAMP, IN VERTICAL PLANE NORMAL TO THE GLOWER. GLOBES AS INDICATED IN THE FIGURE

parallel and normal to the glowers, to which reference has already been made. The use of opal and sand-blasted globes alters the distribution of candle-power in such a way as to diminish the downward intensities and increase the outward and upward intensities.

TABLE II

FOR FIGURES 8 AND 9, SINGLE-GLOWER NERNST LAMP

220 VOLTS, .4 AMPERE

Angle	Candle-power Angle of Vertical Planes to Glower					
	0°	90°	0°	00°	0°	90°
75° A					6.53	6.72
60° A					8.12	8.12
45° A					11.03	12.93
30 A	2.00	1.93	6.70	8 85	13.03	15.87
15° A	2 15	8.10	9.00	18 73	16.01	19.27
Hor.	5.12	34.72	13.29	28.05	19.12	22.02
15° B	15.10	46.83	19.67	32 55	20.07	22.47
30° B	25.45	49.27	27.67	37.13	22.82	24.97
45° B	41.30	54.12	35 85	41.62	22.90	25.01
60° B	51 10	62 01	41.96	42.52	23.78	25.88
75° B	55.12	61.00	46.00	45.37	24.67	25 97
Globes	Clear Globe		Sand-blasted Globe		Pearl Opal Globe	
E. M. F.	223.7		220.5		224.2	
Current	.4		.4		.4	
Watts	89.		88.		89.	
Mean Hemispherical Candle-power	38.7		31.8		21.4	
Watts per Mean Hemispherical Candle-power	2.31		2.78		4.19	
Mean Spherical Candle-power	21.78		20.5		18.1	
Watts per Mean Spherical Candle-power	4.11		4.3		4.95	

In Tables III, IV and V, and in Figures 10 to 15, inclusive, will be found the results of a careful test on the three-glower Nernst lamp, equipped with the various heater cases, globes and shades furnished by the manufacturers. As tested with a constant current of .4 ampere per glower, this lamp consumes approximately 260 watts. It yields mean hemispherical candle-power ranging from 64.3 for the pearl opal ball, to

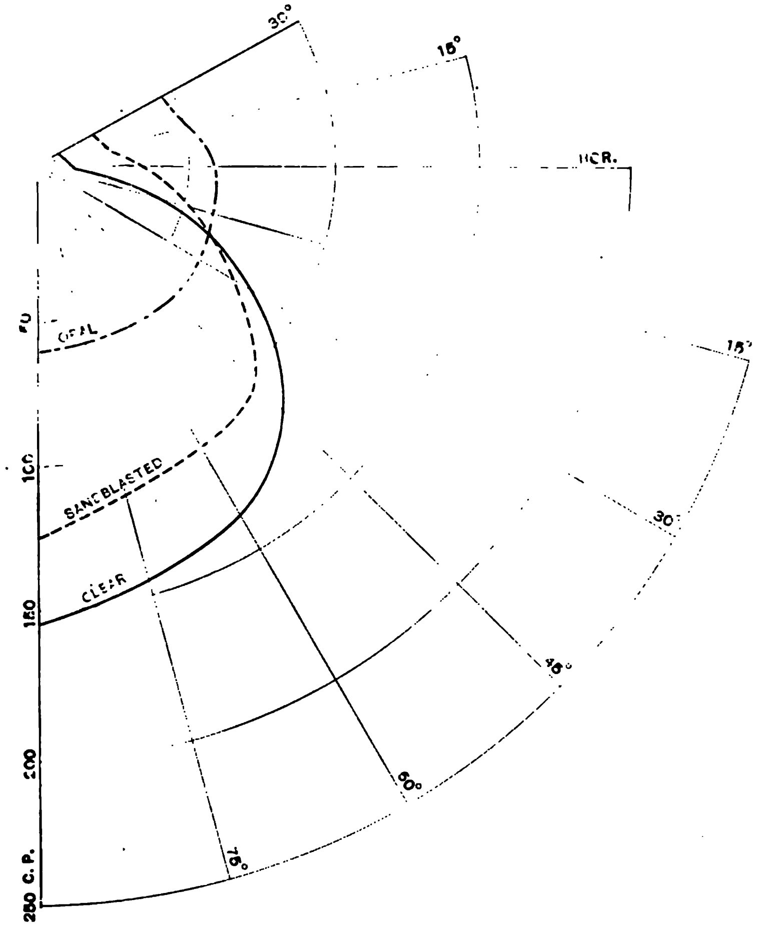


Fig. 10—Distribution of Candle-power in a Plane Parallel to Glowers for Three-Glower Lamp Equipped with Globes as Indicated

118.4 for the clear heater case ; the corresponding values of watts per mean hemispherical candle-power being 4.18 and 2.22.

The wide variation in these values indicates clearly how it is possible to alter the flux of light below the

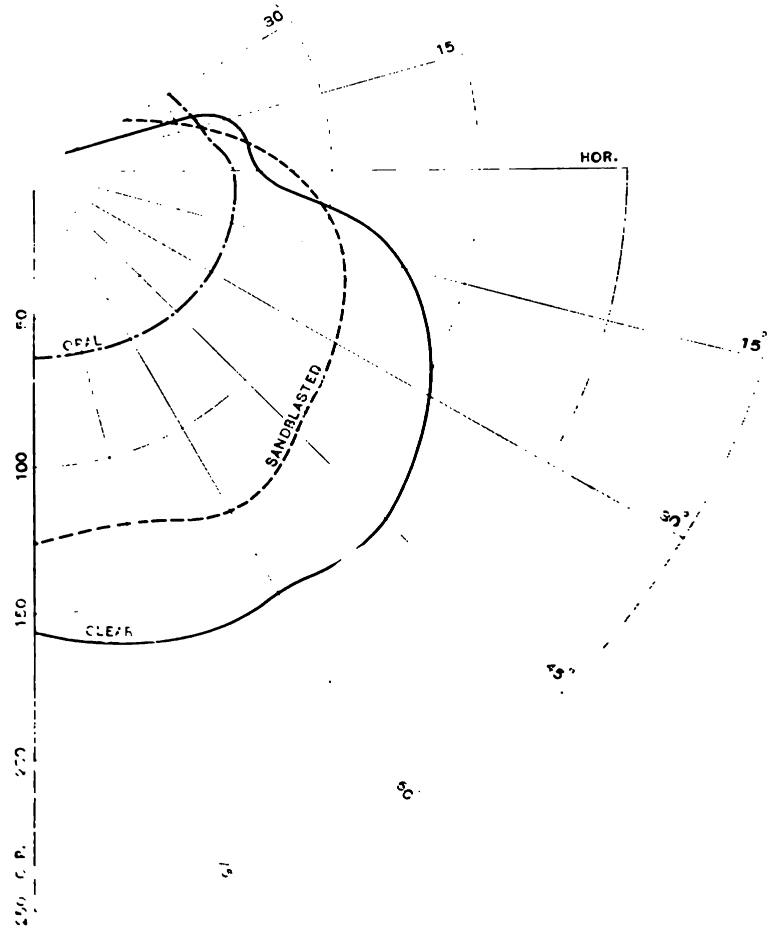


FIG. 11—DISTRIBUTION OF CANDLE-POWER IN A PLANE NORMAL TO GLOWERS FOR THREE-GLOWER LAMP EQUIPPED WITH GLOBE AS INDICATED

horizontal plane by the use of different globes and shades, and is a strong argument against the rating of lamps on the basis of mean hemispherical candle-power, or, for that matter, on any basis that does not take into account the total volume of light emitted by the

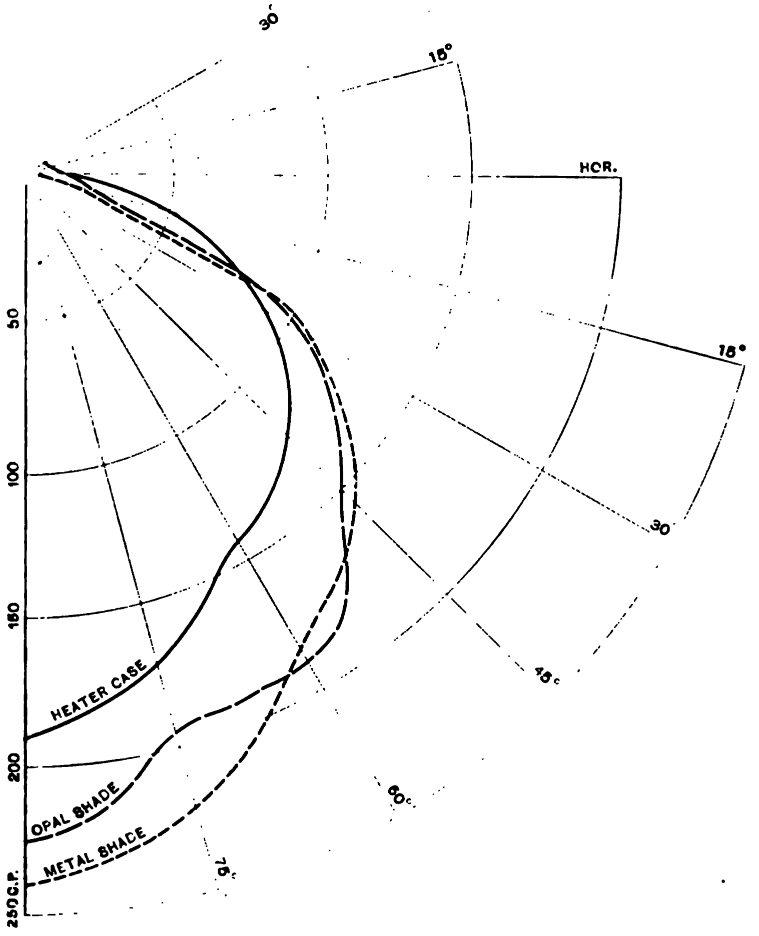


Fig. 12—Distribution of Candle-power in a Plane Parallel to Glower for Three-Glower Lamp Equipped with Clear Heater Case and Shades as Indicated

source. Coming now to a comparison of the light output, based on the mean spherical candle-power, we find a minimum of 51.9 and a maximum of 68.7, the power consumption being the same as in the previous case. The corresponding variation in specific power consumption or watts per mean spherical candle-power,

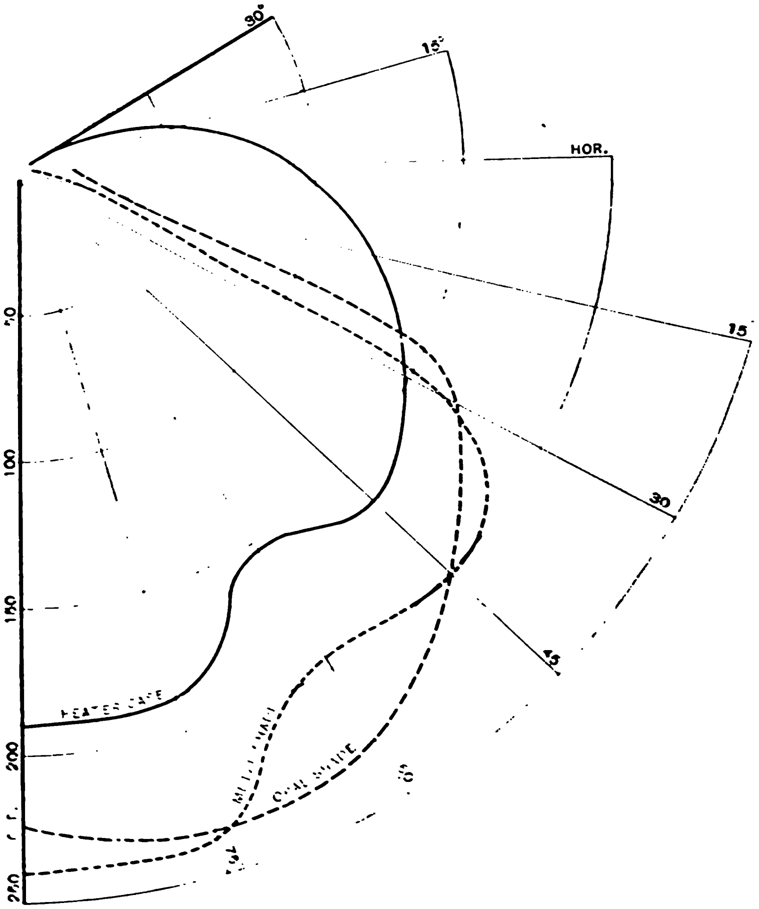


FIG. 13—DISTRIBUTION OF CANDLE-POWER IN A PLANE NORMAL TO GLOWERS FOR THREE-GLOWER LAMP EQUIPPED WITH CLEAR HEATER CASE AND SHADES AS INDICATED

is from 5.00 to 3.84. It is evident that the variation in mean spherical candle-power can be due only to differences in the absorbing power of the globes and shades used. To put the matter in another way, this three-glower lamp, consuming approximately a constant power, is made to yield through the agency of its

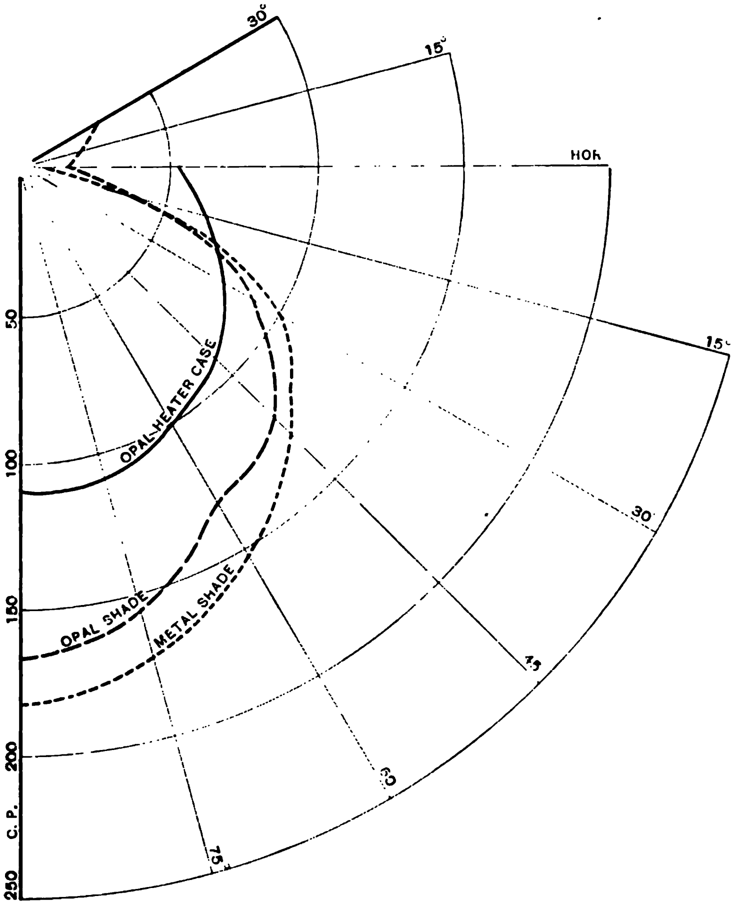


FIG. 14—DISTRIBUTION OF CANDLE-POWER IN A PLANE PARALLEL TO GLOWERS FOR THREE-GLOWER LAMP EQUIPPED WITH OPALESCENT HEATER CASE AND SHADES AS INDICATED

nine different equipments a maximum variation of 84 per cent in mean hemispherical candle-power and a maximum variation of 32 per cent in mean spherical candle-power.

It is worthy of note that the use of a shade on a lamp does not necessarily increase the mean hemispherical candle-power. For instance, a shade extending even slightly below the horizontal may cut down the horizontal candle-power quite markedly; enough, in

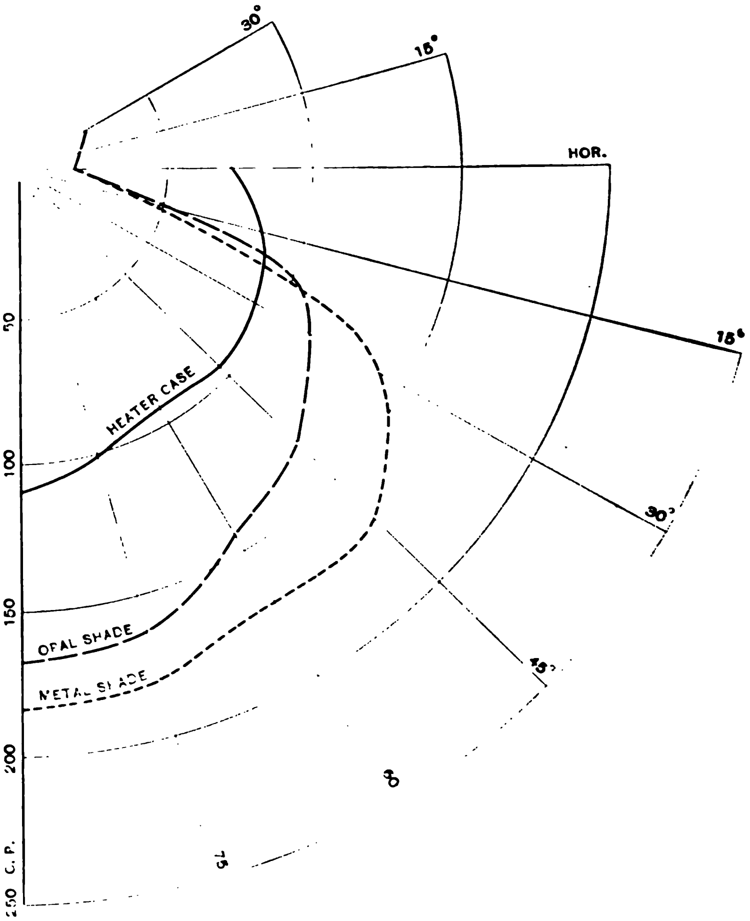


Fig. 15—Distribution of Candle-power in a Plane Normal to Glowers for Three-Glower Lamp Equipped with Opalescent Heater Case and Shades as Indicated

fact, to more than offset the increase in candle-power directly below the lamp. Figure 12 furnishes a good example of this peculiarity. Here the shade cuts off all the light down to about 25 degrees below the horizontal, and in consequence of this fact the mean hemispherical candle-power without shade is slightly greater than the mean hemispherical candle-power with shade, the actual values being 118.4 against 117.4 The results of a similar series of tests on a six-glower Nernst lamp are to be found in Tables VI, VII and VIII, and in Figures 16 to 21, inclusive.

TABLE III

FOR FIGURES 10 AND 11, THREE-GLOWER NERNST LAMP

220 VOLTS, 1.2 AMPERES

Angle	Candle-power Angle of Vertical Planes to Glowers					
	0°	90°	0°	90°	0°	90°
30° A	7.4	11.0	20.1	33.0	46.5	51.5
15° A	9.5	57.7	23.6	57.0	51.7	56.7
Hor.	12.0	75.4	34.9	85.7	58.7	65.7
15° B	41.9	125.5	52.7	106.5	60.3	67.4
30° B	80.0	152.6	77.4	116.0	62.1	68.2
45° B	116.8	167.3	102.5	122.5	64.3	67.2
60° B	134.8	163.9	109.5	132.7	61.6	64.3
75° B	142.7	162.9	115.4	121.9	61.7	61.6

Globes	Clear Globe	Sand-blasted Globe	Pearl Opal Globe
E. M. F.	218.8	219.5	224.
Current	1.2	1.2	1.2
Watts	262.	263.	268.
Mean Hemispherical Candle-power	112.6	96.9	64.3
Watts per Mean Hemispherical Candle-power	2.33	2.72	4.18
Mean Spherical Candle-power	65.1	61.5	55.5
Watts per Mean Spherical Candle-power	4.04	4.28	4.85

Curves of Figures 16 to 21 have the same general contour as those for the three-glower lamp. It will be noted, however, that the test includes a type of globe not found in the tests previously described, namely, the opalescent globe. It is interesting to note the relative candle-power of the one, three and six-glower lamps. In Figures 22 and 23 will be found distribution curves plotted to the same scale for the three lamps with two different equipments, namely, clear and opal globes. These curves are the mean of parallel and normal distributions. The relative power consumption per unit of candle-power is shown in Table XI, which gives the watts per mean hemi-

TABLE IV

FOR FIGURES 12 AND 13, THREE-GLOWER NERNST LAMP

220 VOLTS, 1.2 AMPERES

Angle	Candle-power Angle of Vertical Planes to Glowers					
	0°	90°	0°	90°	0°	90°
30° A	6.7	9.4				
15° A	7.5	50.8				
Hor.	16.3	91.3	4.0	5.3	15.1	18.2
15° B	52.1	124.2	18.2	23.9	22.9	30.9
30° B	91.4	148.9	108.8	158.3	105.5	168.0
45° B	123.8	166.0	156.0	202.2	149.0	201.4
60° B	142.3	152.3	175.0	196.8	190.5	228.0
75° B	169.8	187.7	221.0	237.6	193.9	236.0
Globes	Clear Heater Case		Clear Heater Case, Metal Shade		Clear Heater Case, Opal Shade	
E. M. F.	219.5		219.5		220.	
Current	1.2		1.2		1.2	
Watts	263.		263.		264.	
Mean Hemispherical Candle-power	118.4		117.4		118.3	
Watts per Mean Hemispherical Candle-power	2.22		2.25		2.23	
Mean Spherical Candle-power	68.7		58.7		68.5	
Watts per Mean Spherical Candle-power	3.84		4.49		3.86	

spherical and per mean spherical candle-power for each of the three types of lamp.

The table shows clearly that the three-glower lamp is slightly more efficient than the single-glower lamp and the six-glower lamp considerably more efficient than the three-glower. This increase in efficiency can be accounted for, if we remember that a number of glowers in close proximity must, through mutual radiation, operate at higher temperature than would an isolated glower. This will be true in spite of the fact that multiple glowers must screen the light from one another in certain directions, dependent upon their

TABLE V

FOR FIGURES 14 AND 15, THREE-GLOWER NERNST LAMP

220 VOLTS, 1.2 AMPERES

Angle	Candle-power Angle of Vertical Planes to Glowers					
	0°	90°	0°	90°	0°	90°
30° A					27.5	26.6
15° A					20.6	21.6
Hor.	51.2	71.4	7.0	7.6	16.2	18.6
15° B	63.8	85.5	40.8	43.7	37.6	47.0
30° B	78.9	91.8	100.3	140.0	89.3	110.8
45° B	92.8	95.2	129.1	168.9	121.0	131.5
60° B	100.1	92.8	151.7	170.8	131.3	143.0
75° B	108.7	101.2	172.0	179.9	154.8	163 2
Globes	Opal Heater Case		Opal Heater Case. Metal Shade		Opal Heater Case, Opal Shade	
E. M. F.	220.7		220.		220.5	
Current	1.2		1.2		1.2	
Watts	264.		264.		264.	
Mean Hemispherical Candle-power	85.6		103.7		90 8	
Watts per Mean Hemispherical Candle-power	3.09		2.54		2.91	
Mean Spherical Candle-power	58.2		51.9		54.1	
Watts per Mean Spherical Candle-power	4.55		5.09		4.89	

arrangement in the holder. Thus, if the number of glowers be increased, in the type of lamp with which we are dealing in these tests, the horizontal intensity will not increase in the same ratio as the downward intensity, because of the screening action of one glower upon another. Figure 24 brings out this fact very clearly. Here, the ordinates are candle-power values normal to the glowers in a horizontal plane, and the abscissæ the number of glowers in service. The candle-power seems to increase approximately proportionally to the number of glowers, but doubling the number

TABLE VI

FOR FIGURES 16 AND 17, SIX-GLOWER NERNST LAMP

220 VOLTS, 2.4 AMPERES

Angle	Candle-power Angle of Vertical Planes to Glowers							
	0°	90°	0°	90°	0°	90°	0°	90°
30° A	18.0	60.9	51.3	71.8	61.5	83.7	101.8	116.2
15° A	18.7	90.6	60.6	104.1	80.4	114.0	119.2	133.4
Hor.	41.4	113.9	90.9	154.6	118.3	168.6	140.6	159.9
15° B	125.4	322.7	147.5	254.8	170.5	232.5	152.2	177.1
30° B	247.6	374.0	216.7	291.1	231.7	288.7	166.1	181.9
45° B	319.6	414.4	273.8	299.3	298.8	328.0	171.9	187.7
60° B	350.7	396.9	273.8	289.0	320.9	320.7	164.2	170.4
75° B	367.6	399.3	287.0	297.6	333.0	307.4	162.6	162.9
Globes	Clear Globe		Sand-blasted Globe		Opalescent Globe		Pearl Opal Globe	
E. M. F.	226.0		228.3		226.5		229.5	
Current	2.4		2.4		2.4		2.4	
Watts	542.		547.		543.		550.	
Mean Hemispherical Candle-power	289.2		239.1		258.6		169.3	
Watts per Mean Hemispherical Candle-power	1.88		2.29		2.10		3.25	
Mean Spherical Candle-power	163.9		150.4		168.6		137.4	
Watts per Mean Spherical Candle-power	3.30		3.64		3.22		4.01	

of glowers does not, by any means, double the candle-power. The horizontal arrangement of glowers does not tend to produce strong horizontal candle-power, except, of course, in the case of the single-glower lamp. Furthermore, the normal candle-power must inevitably be considerably greater than the "end-on" candle-power. The glowers may be so arranged as greatly to increase the normal candle-power without increasing the "end-on" candle-power. Figure 25 shows very clearly the effect of three different arrangements of the glowers with respect to the heaters.

TABLE VII

FOR FIGURES 18 AND 19, SIX-GLOWER NERNST LAMP

220 VOLTS, 2.4 AMPERES

Angle	Candle-power Angle of Vertical Planes to Glowers					
	0°	90°	0°	90°	0°	90°
30° A	21.3	50.2	8.7	11.3	42.7	52.3
15° A	22.4	93.2	8.4	11.0	36.9	47.9
Hor.	31.4	128.4	9.5	10.9	32.4	42.8
15° B	130.4	295.3	48.3	66.0	52.3	86.3
30° B	228.5	369.7	272.6	410.2	270.2	412.0
45° B	306.1	398.0	367.9	465.1	360.2	445.3
60° B	360.7	410.7	409.7	464.3	393.1	442.4
75° B	404.0	420.2	478.9	517.6	429.7	473.8
Globes	Clear Heater Case		Clear Heater Case, Metal Shade		Clear Heater Case, Opal Shade	
E. M. F.	226.5		227.		226.	
Current	2.4		2.4		2.4	
Watts	543.		544.		542.	
Mean Hemispherical Candle-power	285.7		262.4		264.2	
Watts per Mean Hemispherical Candle-power	1.90		2.08		2.05	
Mean Spherical Candle-power	162.1		131.2		155.8	
Watts per Mean Spherical Candle-power	3.36		4.15		3.48	

The effects are precisely those that would be expected, and discussion of them is hardly necessary.

Although the six-glower Nernst lamp takes about 20 per cent more power than either the direct or alternating-current arc lamps commonly used, yet it is, as regards maximum candle-power, a light source of the same order of brightness, and hence a comparison of the three sources is justifiable. Figure 26 shows the mean distribution curve of the six-glower Nernst lamp, equipped with both clear and opal globes, plotted on the same sheet with the curves for standard multiple and series, direct and alternating

TABLE VIII

FOR FIGURES 20 AND 21, SIX-GLOWER NERNST LAMP

220 VOLTS, 2.4 AMPERES

Angle	Candle-power Angle of Vertical Planes to Glowers					
	0°	90°	0°	90°	0°	90°
30° A	61.5	85.2	8.7	10.9	50.5	55.2
15° A	83.3	120.8	8.4	9.2	42.9	49.5
Hor.	115.4	168.8	8.2	8.3	36.9	41.4
15° B	162.8	224.7	111.3	111.0	62.3	131.7
30° B	216.3	252.6	282.6	287.6	266.7	327.7
45° B	259.7	274.6	369.7	364.2	332.5	376.6
60° B	288.8	281.9	409.6	403.8	351.0	382.7
75° B	295.0	291.9	407.0	434.4	378.2	395.9
Globes	Opal Heater Case		Opal Heater Case, Metal Shade		Opal Heater Case, Opal Shade	
E. M. F.	225.5		226.		227.5	
Current	2.4		2.4		2.4	
Watts	541.		542.		546.	
Mean Hemispherical Candle-power	234.2		253.8		243.3	
Watts per Mean Hemispherical Candle-power	2.31		2.14		2.24	
Mean Spherical Candle-power	156.0		126.9		148.9	
Watts per Mean Spherical Candle-power	3.47		4.27		3.67	

current arcs. (See Table XII.) These arc curves have been taken from previous reports of the committee. The lamps on which these measurements

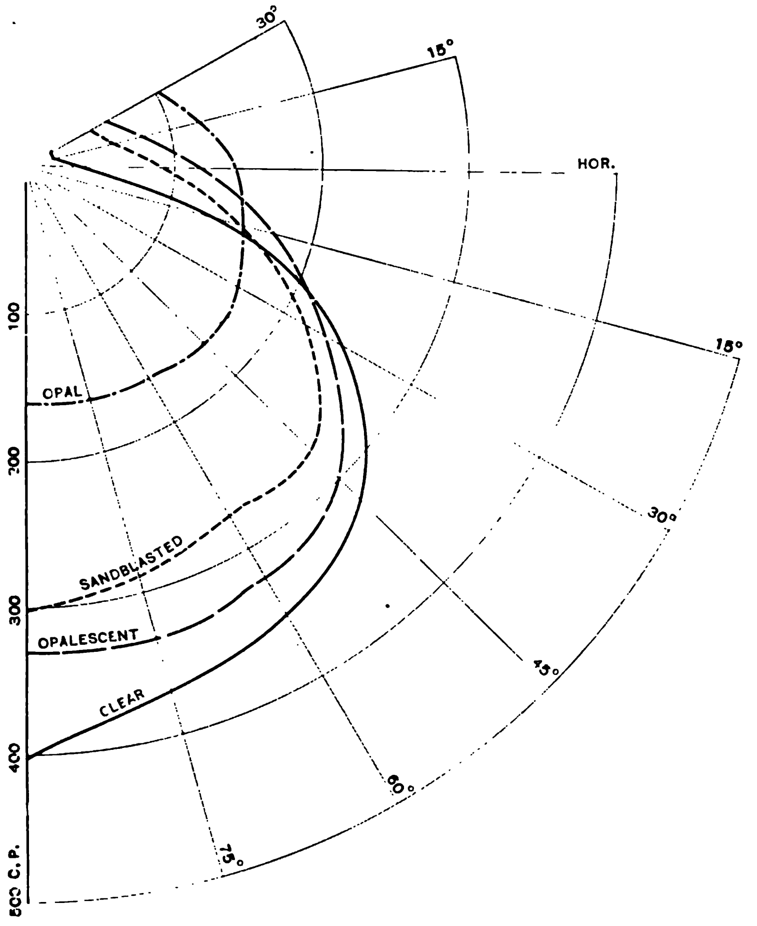


Fig. 16—Distribution of Candle-power in a Plane Parallel to Glowers for Six-Glower Lamp Equipped with Globes as Indicated

were made were equipped respectively for interior and street service: the multiple direct and alternating-current arc lamps and the direct-current series arc lamp having opalescent inner globes and clear outer globes, and the alternating-current 7.5-ampere series arc lamp having an opalescent inner globe and a metal shade.

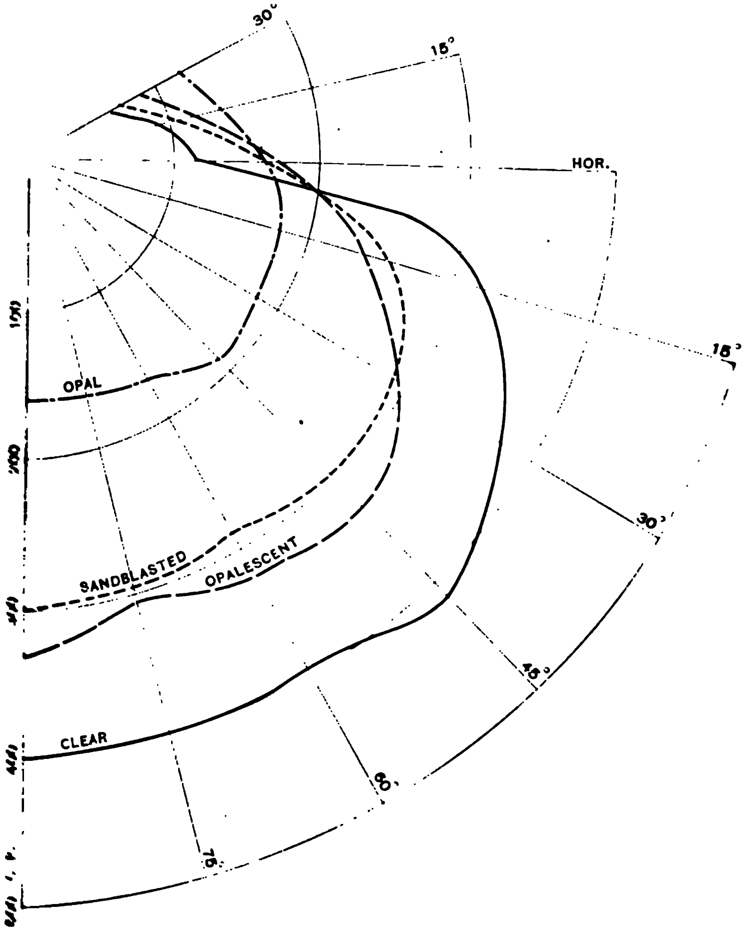


Fig. 17—Distribution of Candle-power in a Plane Normal to Glowers for Six-Glower Lamp Equipped with Globes as Indicated

It will be noted that the candle-power distribution of the Nernst lamp is altogether different from that of the arc lamps. The Nernst lamp is strong where the arc lamps are weak, and *vice versa.* The points of intersection of the curves form segments that show the superiority in certain zones of the several lamps.

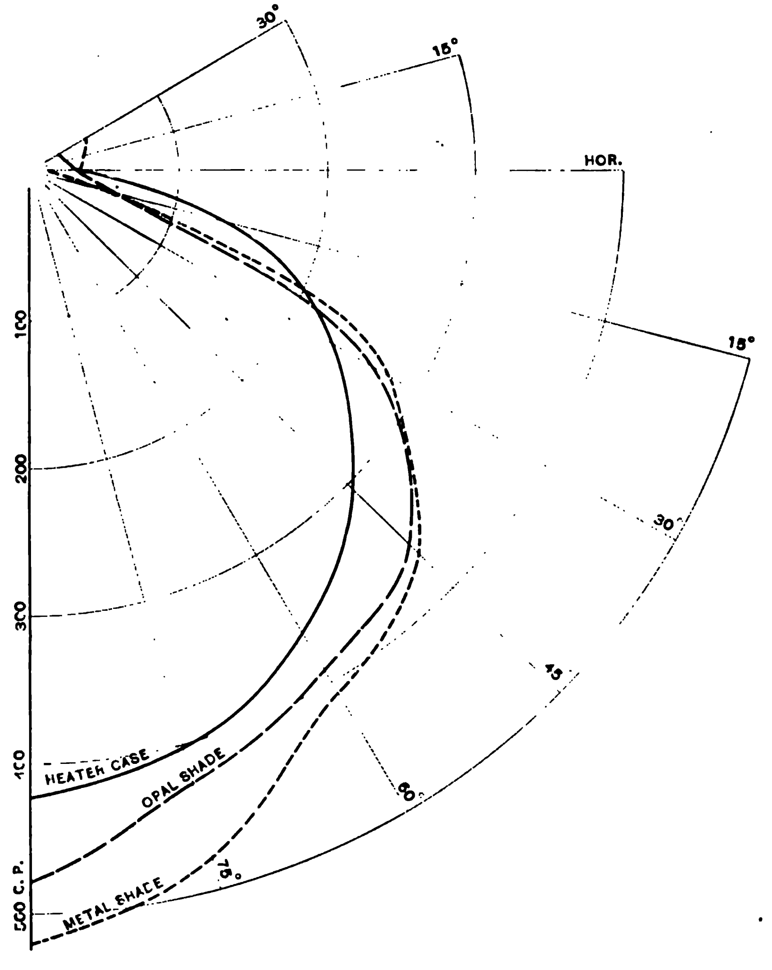


FIG. 18—DISTRIBUTION OF CANDLE-POWER IN A PLANE PARALLEL TO GLOWERS FOR SIX-GLOWER LAMP EQUIPPED WITH CLEAR HEATER CASE AND OPAL AND METAL SHADES AS INDICATED

Those who prefer to study curves of illumination, rather than curves of candle-power, will find in

Figure 27 a normal illumination plotted as ordinates against distances from the lamp along the horizontal

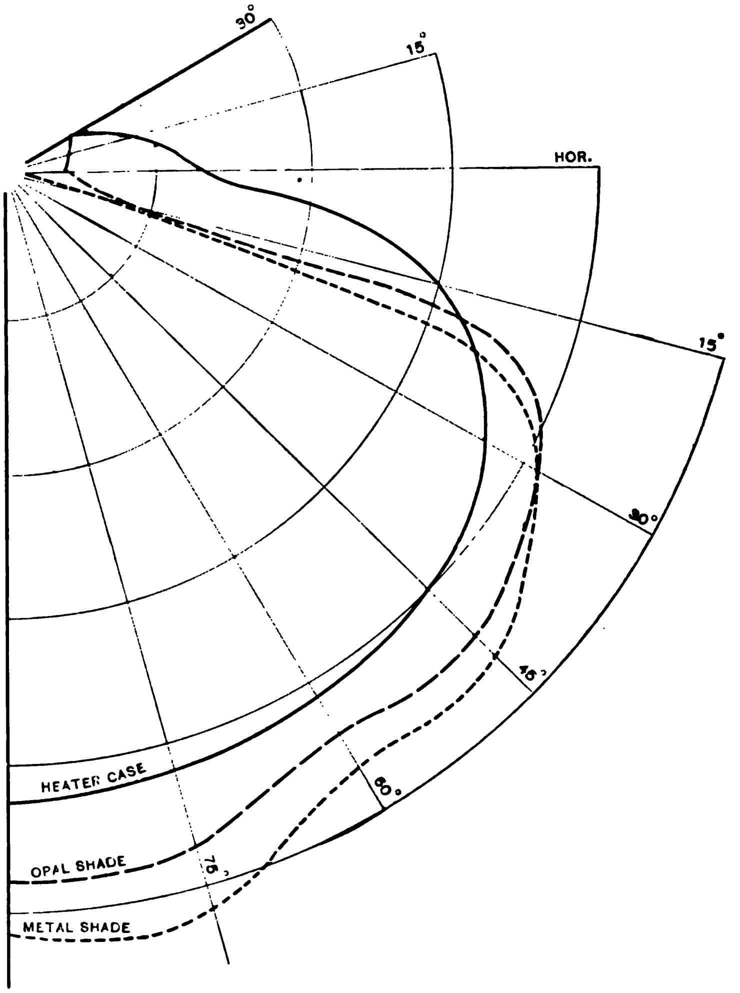


Fig. 19—Distribution of Candle-power in a Plane Normal to Glowers for Six-Glower Lamp Equipped with Clear Heater Case and Opal and Metal Shades as Indicated

as abscissæ. All three lamps are suspended at a height of 25 feet from the ground. Owing to the fact that the curves are very flat, and hence difficult to read at distances greater than 100 feet, it has

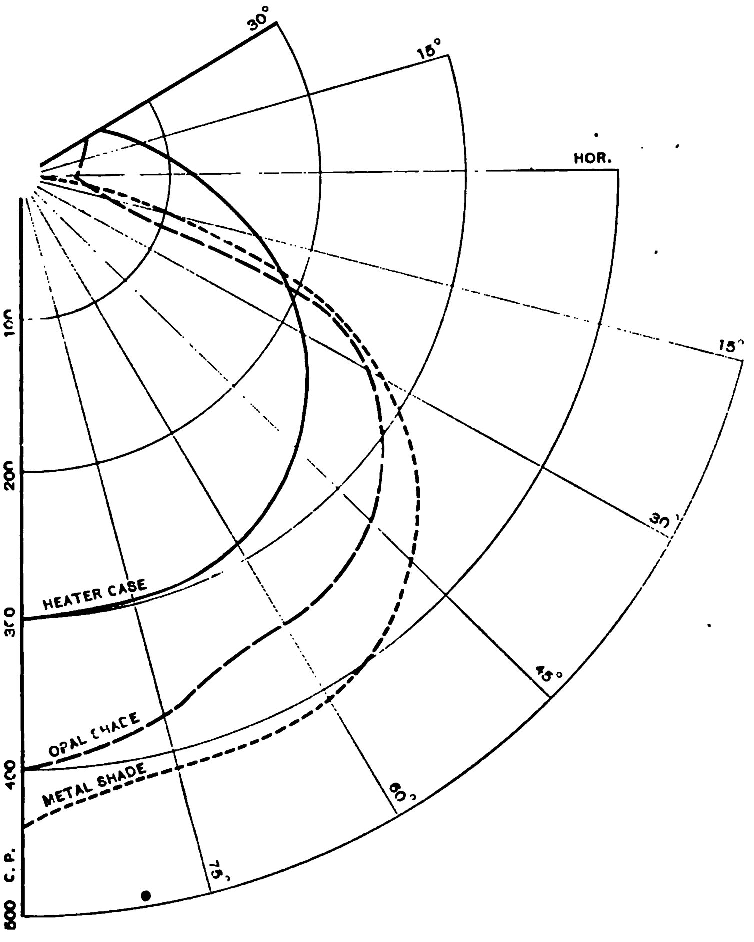


FIG. 20—DISTRIBUTION OF CANDLE-POWER IN A PLANE PARALLEL TO GLOWERS FOR SIX-GLOWER LAMP EQUIPPED WITH OPALESCENT HEATER CASE AND OPAL AND METAL SHADES AS INDICATED

seemed expedient to plot the right-hand portions of these curves to a larger scale in Figure 28. Because of the strong intensity of the Nernst lamp below 45 degrees from the horizontal, the illumination of points somewhat remote will, in general, be enhanced as the lamp is raised. This point is very clearly shown in

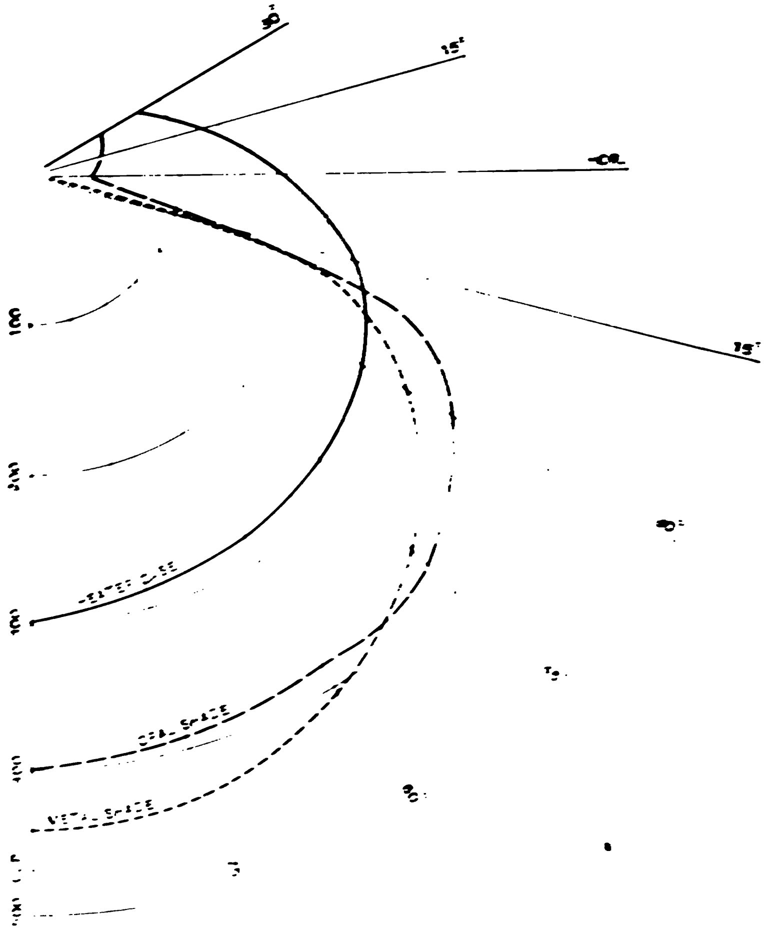


Fig. 21—Distribution of Candle-power in a Plane Normal to Glowers for Six-Glower Lamp Equipped with Opalescent Heater Case and Opal and Metal Shades as Indicated.

Figure 29, which exhibits the illumination in candle-feet due to the six-glower Nernst lamp, at distances ranging from 50 to 150 feet from the base of the pole for various pole heights, ranging from 25 to 50 feet. A single example will illustrate the use of these curves. Suppose that maximum illumination is desired at a point 50 feet from the base of the pole. The lamp should be placed at a height of 25 feet;

TABLE IX

FOR FIGURE 25, SIX-GLOWER NERNST LAMP

220 VOLTS, 2.4 AMPERES. SPECIAL ARRANGEMENT OF GLOWERS

Angle	Candle-power		
	Arrangement 1	Arrangement 2	Arrangement 3
30° A	60.9	67.1	94.5
15° A	90.6	126.0	106.5
Hor.	113.9	222.4	196.2
15° B	322.7	289.7	267.4
30° B	374.0	350.9	318.4
45° B	414.4	415.9	369.7
60° B	396.9	381.2	356.0
75° B	399.3	368.9	375.9

Clear Globe—Normal to Glowers.

TABLE X

FOR FIGURE 7, SIX-GLOWER NERNST LAMP

EQUIPPED WITH CLEAR GLOBE

Angle	Candle-power Angle of Vertical Plane to Glowers							
	0°	15°	30°	45°	60°	75°	90°	Mean
30° A	18.0	19.4	21.8	28.7	48.0	6 .0	60.9	36.7
15° A	18.7	20.8	37.8	51.7	72.9	87.2	90.6	54.2
Hor.	41.4	69.1	79.9	92.3	101.8	108.8	113.9	86.7
15° B	125.4	175.6	232.0	267.8	299.5	322.5	322.7	248.1
30° B	247.6	282.2	324.8	359.4	367.1	386.9	374.0	334.6
45° B	319.6	339.6	356.8	375.3	391.9	411.5	414.4	372.7
60° B	350.7	342.8	344.1	392.2	386.1	393.3	396.9	372.3
75° B	367.6	377.4	376.3	384.8	391.7	361.8	399.3	379.9

anything lower or higher would diminish the illumination at this particular point. To secure maximum

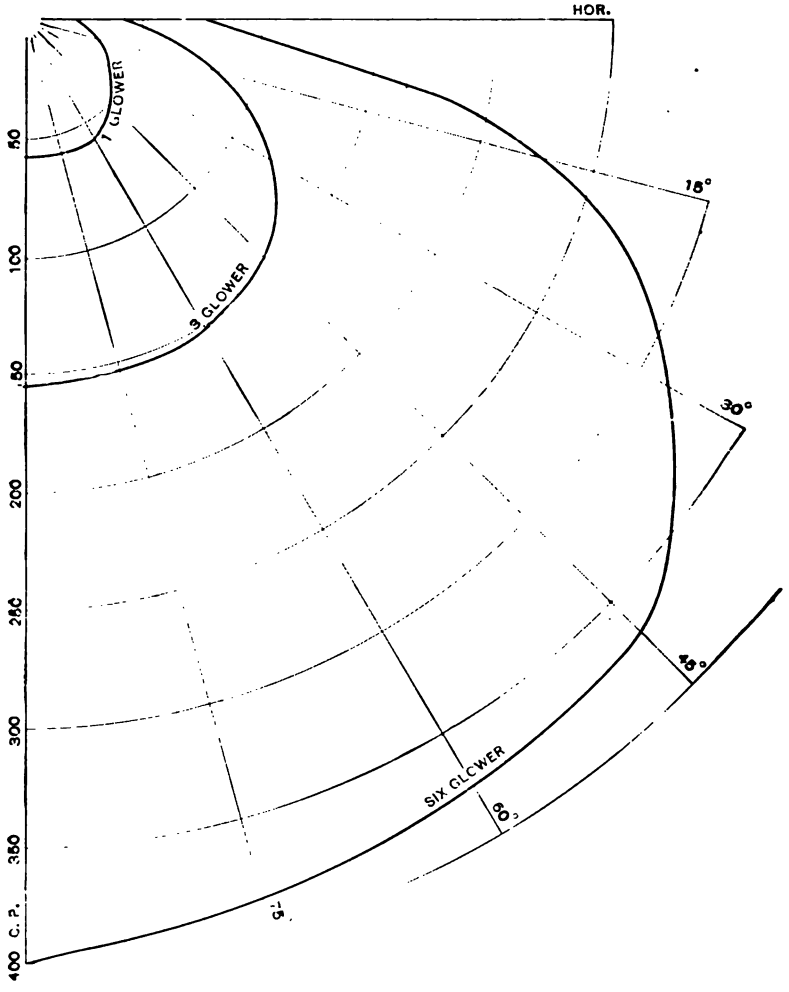


FIG. 22—MEAN DISTRIBUTION CURVES OF LAMPS EQUIPPED WITH CLEAR GLOBE.

illumination at a point as far away as 150 feet would require a height of lamp, in most cases, impracticable

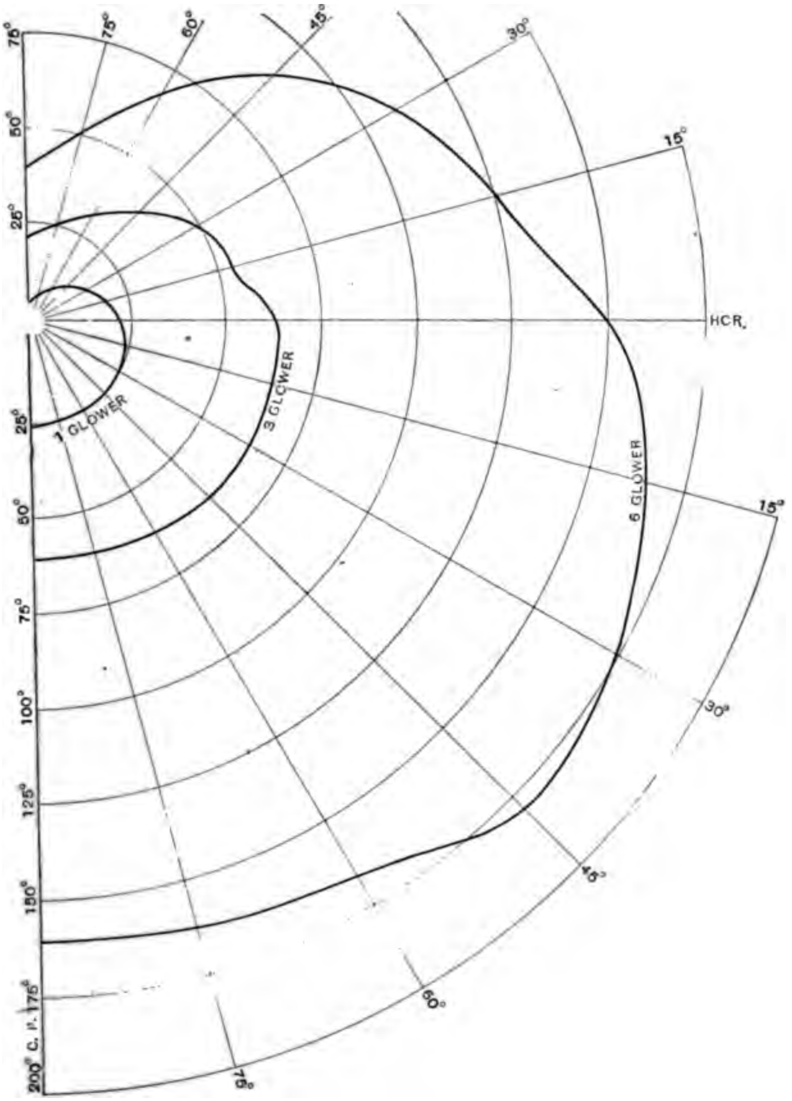


FIG. 23—MEAN DISTRIBUTION CURVES OF LAMPS EQUIPPED WITH PEARL OPAL GLOBES

to attain. It is obvious that the placing of a lamp so as to secure maximum illumination at some particular point is usually a matter irreconcilable with the attainment of maximum *mean* illumination over a given distance. Figure 30 shows the mean illumination between 50 and 150 feet, and also the illumination at 150 feet for the Nernst lamp suspended at various heights, ranging from 15 to 50 feet.

TABLE XI

RELATIVE POWER CONSUMPTION PER CANDLE-POWER OF ONE, THREE AND SIX-GLOWER LAMPS WITH VARIOUS GLOBES AND HEATER CASES

WATTS PER MEAN HEMISPHERICAL CANDLE-POWER

Number of Glowers	Opal Heater Case	Clear Heater Case	Clear Globe	Opal Globe	Sand blasted Globe
1			2.31	4.19	2.78
3	3.09	2 22	2.33	4 18	2.72
6	2.31	1.90	1.88	3 25	2 29

WATTS PER MEAN SPHERICAL CANDLE-POWER

Number of Glowers	Opal Heater Case	Clear Heater Case	Clear Globe	Opal Globe	Sand-blasted Globe
1			4.11	4.95	4.30
3	4.55		4 04	4.85	4.28
6			3.30	4.01	3.64

PHOTOMETRY OF THE MANTLE GAS BURNER

With a view of getting representative results on gas mantles of the Welsbach type, a variety of mantles were purchased in the open market. These mantles were classified according to their retail price, as follows:

Class A—Retail price, 35 to 60 cents
Class B—Retail price, 20 to 30 cents
Class C—Retail price, below 20 cents

TABLE XII

FOR FIGURE 26

Angle	Multiple D. C. Arc C. P.	Multiple A. C. Arc C. P.	Series D. C Arc C. P.	Series A. C. Arc C. P.	Nernst 6-Glower	Nernst 6-Glower
15° A	176	163	285	215	37	97
Hor.	202	167	359	310	87	146
15° B	252	186	397	375	248	205
30° B	283	191	415	440	335	263
45° B	260	169	375	445	373	315
60° B	201	134	295	420	372	320
75° B	156	88	200	355	380	320
90° B					400	330
Globes	**Opal Inner, Clear Outer**	**Opal Inner, Clear Outer**	**Opal Inner, Clear Outer**	**Opal Inner, Metal Shade**	**Clear Globe**	**Opal Globe**
E. M. F.	110	110	71.6	73.8	226	226.5
Current	4.9	6.29	6.55	7.5	2.4	2.4
Watts	529	417	469	469	542	543
Power Factor	1	.6	1	.83	1	1
Mean Spherical Candle-power	182	140			163.9	168.6
Mean Hemispherical Candle-power	239	167	360	394	289	258.6
Watts per Candle-power: Spherical	2.90	3.02			3.30	3.22
Watts per Candle-power: Hemispherical	2.25	2.53	1.3	1.19	1.88	2.10

From the first, great difficulty was had in the photometric work on gas sources, because of variability in the gas pressure in the service mains at Purdue University. That the candle-power of a gas mantle is dependent in a marked degree upon the gas

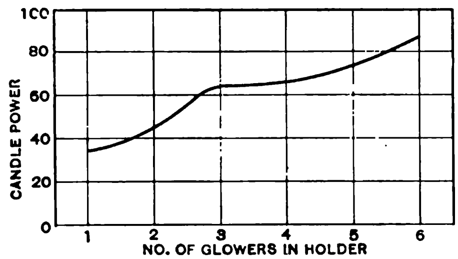


FIG. 24—SCREENING EFFECT OF GLOWERS AT HORIZONTAL, NORMAL TO GLOWERS

pressure, is clearly shown in Figure 31, which exhibits the candle-power in a horizontal direction for different gas pressures, ranging from 1.6 to 2.8 inches of water.

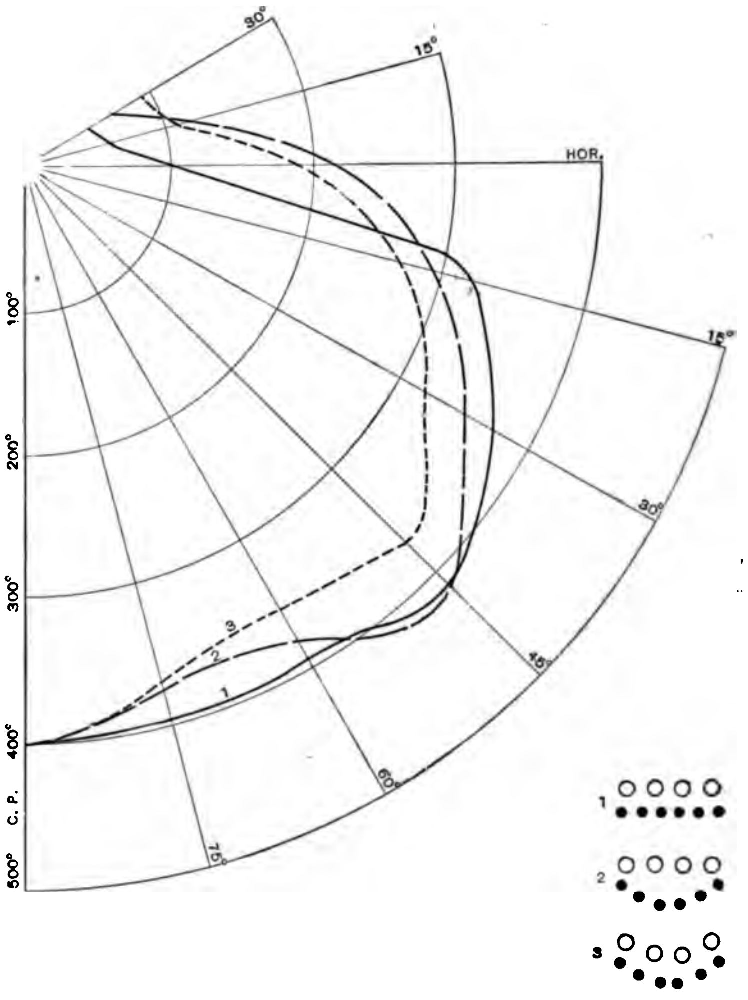


Fig. 25—Distribution of Candle-power about Six-Glower Lamp Equipped with Clear Ball with Special Arrangement of Glowers to Show Screening Effect Normal to Glowers

These results were obtained with the orifice of the burner so adjusted as to give maximum candle-power for each pressure. These results make it clear that candle-power measurements on mantle burners are meaningless unless conducted under conditions of constant pressure.

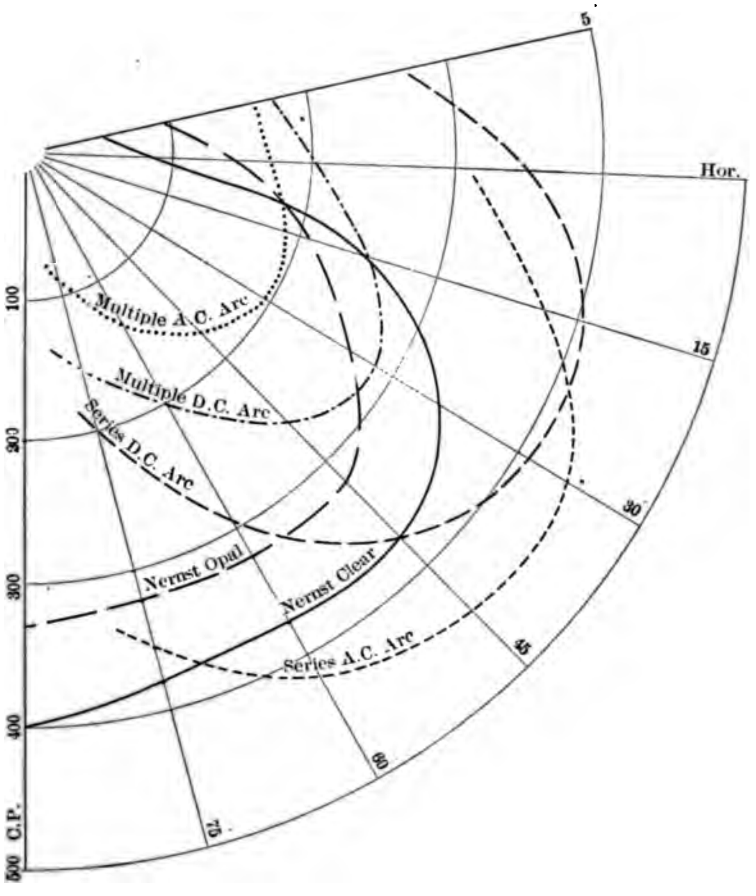


FIG. 26—COMPARATIVE DISTRIBUTION CURVES OF NERNST AND ARC LAMPS

Failing in various expedients to control the gas pressure with sufficient exactness during the daytime, the experimenters were compelled to make all gas measurements after midnight, as it was found that

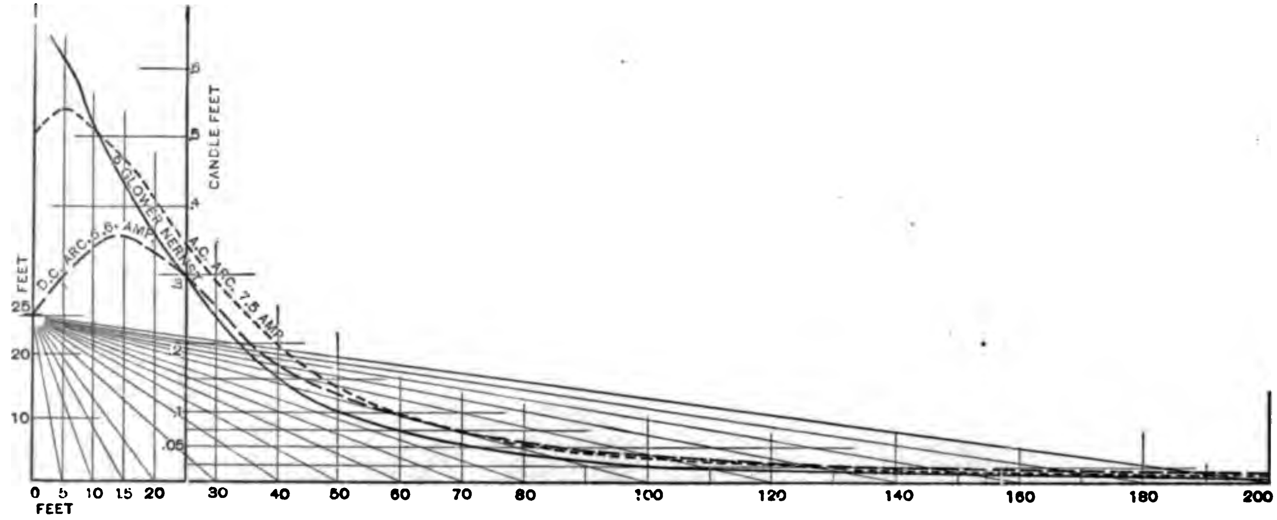


FIG. 27—COMPARATIVE NORMAL ILLUMINATION CURVES OF SERIES ARC AND SIX-GLOWER NERNST LAMPS

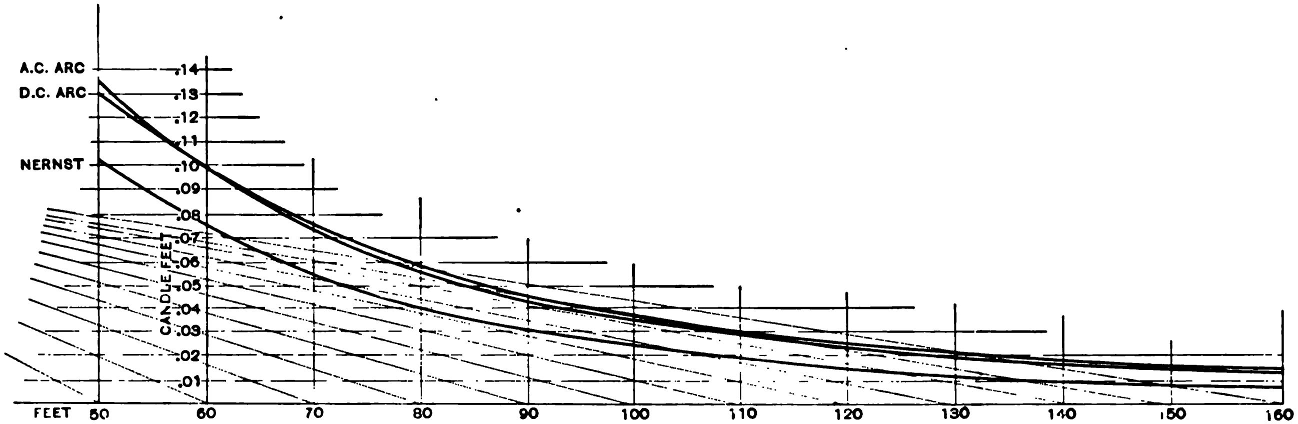


FIG. 28—NORMAL ILLUMINATION (FROM 50 TO 150 FEET) OF SERIES ARC LAMPS AND SIX-GLOWER NERNST LAMP EQUIPPED WITH CLEAR GLOBE

uniform pressure could be depended upon during the early hours of the morning.

Figure 32 shows the horizontal distribution of candle-power about an ordinary gas mantle mounted in a burner having three side supports for the mantle. It is clear that the distribution would be practically a circle were it not for the screening effects of these supporting rods. It will be noted that there are three depressions in the curve corresponding to the positions of the rods. The minimum horizontal candle-power in this instance is about 57, the maximum about 76. The position of the supporting rods is indicated in the middle of the figure.

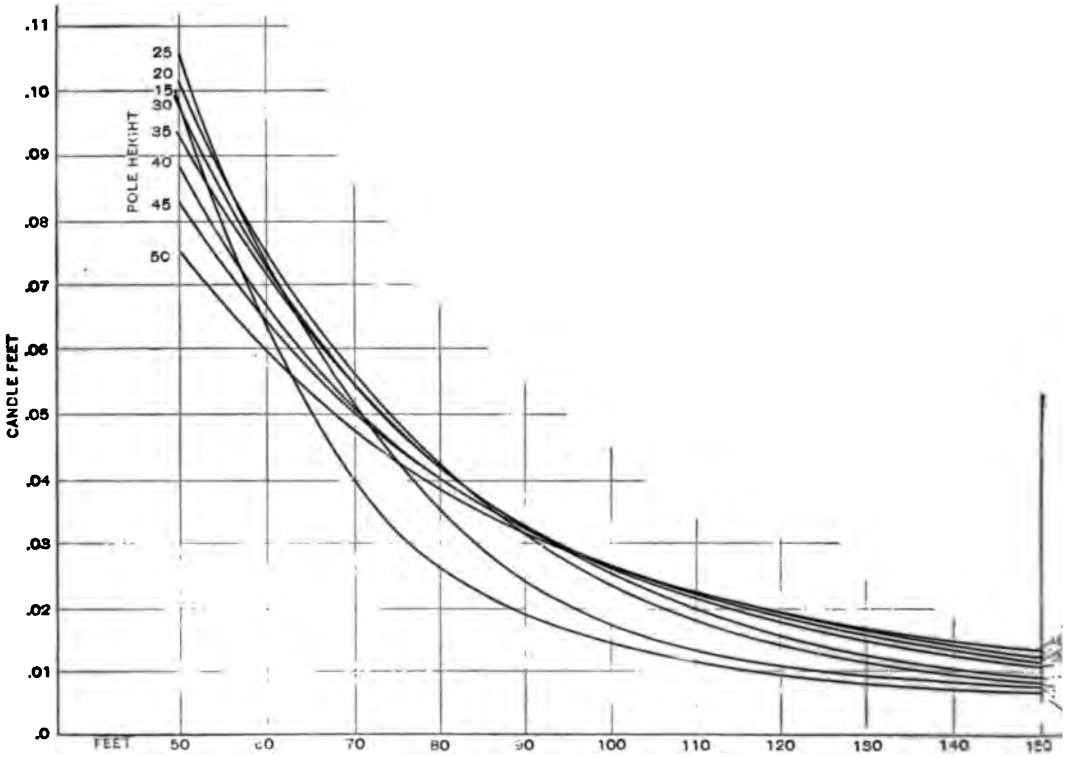


Fig. 29—Effect of Varying the Height of the Six-Glower Nernst Lamp

In Table XIII and Figure 33 are to be found the results of tests of four samples of Class "A" mantles, inclosed in a clear glass chimney, but without other globe or shade. This wing-shaped distribution of candle-power in a vertical plane is characteristic of the ordinary gas mantle. The maximum candle-power is found at about 15 degrees above the horizontal, because from this point of view the visible area of incandescent surface is probably a maximum. It will be noted that samples 10 and 12 depart considerably from the mean, the maximum variation from the mean being perhaps 10 per cent, in the case of sample 10, at 15 degrees above the horizontal. On account of the position of the maximum candle-power in these curves, the mean hemispherical candle-power is uniformly larger above than below the horizontal. The mean gas consumption for Class "A" mantles working

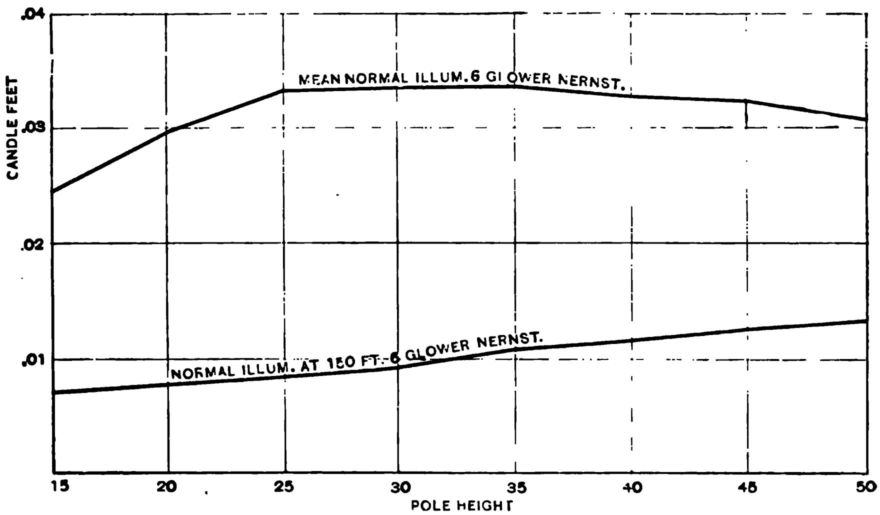


FIG. 30—EFFECT OF VARYING POLE HEIGHT ON MEAN ILLUMINATION 50 TO 150 FEET, AND ON ILLUMINATION AT 150 FEET, SIX-GLOWER NERNST LAMP

The effect upon the candle-power distribution of the mantle burner of different types of shades, is very clearly shown in Figure 37. This figure shows the alteration in the shape of the candle-power curve, produced by the use of two types of porcelain shade, indicated in the figure, and one type of holophane globe. This last globe reduces the maximum at 15 degrees above, and increases correspondingly the downward candle-power in angles below 45 degrees. An inspection of the figures for mean spherical candle-power in Table XVI shows that the use of por-

TABLE XIII

FOR FIGURE 33, CLASS "A"—INCANDESCENT GAS MANTLES

Angle	Candle-power				
	No. 9	No. 10	No. 11	No. 12	Mean
75° A	29.4	26.4	28.3	25.8	27.5
60° A	37.8	38.8	38.4	37.5	38.2
45° A	55.6	55.8	57.5	61.3	57.6
30° A	64.0	60.9	64.8	68.6	64.6
15° A	77.6	68.6	76.0	83.0	76.3
Hor.	67.4	62.2	68.8	74.1	68.1
15° B	64.4	59.3	68.0	63.5	63.8
30° B	63.0	57.0	68.5	66.4	63.7
45° B	53.5	45.0	52.0	49.0	49.9
60° B	36.4	26.4	24.9	29.2	29.2
75° B	3.7	3.5	3.5	3.6	3.6
Cubic Feet Gas Used per Hour...	3.6	3.33	4.0	4.24	3.79
Mean Hemispherical Candle-power—					
Upper..	60.0	56.5	60.4	59.2	59.
Lower......................	54.1	47.9	55.0	53.4	52.6
Mean Spherical Candle-power...	57.1	52.2	57.7	56.3	55.8
Cubic Feet of Gas Used per Mean Hemispherical Candle-power—					
Upper......	.060	.059	.066	.071	.064
Lower.....................	.066	.069	.073	.079	.072
Cubic Feet Gas Used per Mean Spherical Candle-power........	.063	.064	.069	.075	.068

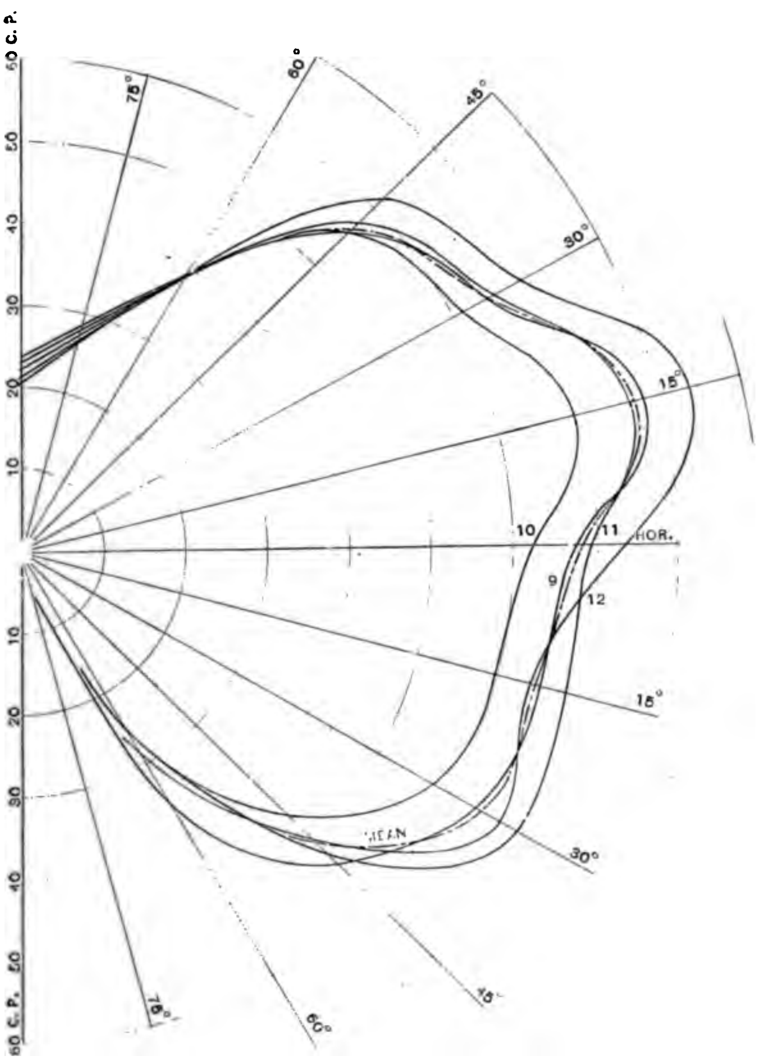


FIG. 33—DISTRIBUTION OF CANDLE-POWER ABOUT CLASS "A" INCANDESCENT GAS MANTLES

celain shades on a mantle burner is accompanied by very slight reduction of total flux of light from the source. The absorption produced by the holophane globe is about 13 per cent.

Figure 38 exhibits the illumination on a plane normal to the ray produced by the mantle burner placed at a height of 12 feet above the street. The illumination varies from the maximum of .187 candle-feet at a distance of 10 feet, to .0105 candle-feet at a distance of 80 feet. Changing the height of the burner has but little effect on the illumination at points beyond 50 feet from the lamp, but changes in

TABLE XIV

FOR FIGURE 34, CLASS "B"—INCANDESCENT GAS MANTLES

Angle	Candle-power						
	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	Mean
75° A	28.8	29.1	24.6	20.5	26.7	26.7	26.0
60° A	44.1	45.5	36.5	32.2	38.2	37.6	39.0
45° A	68.8	58.5	55.3	51.4	56.5	55.4	57.7
30° A	78.7	71.6	65.3	57.4	63.0	63.2	66.5
15° A	85.0	85.0	78.0	68.5	71.8	74.0	77.1
Hor.	84.5	77.1	66.9	62.0	64.1	66.0	70.1
15° B	83.0	70.8	62.6	56.5	62.0	62.1	66.3
30° B	80.4	74.0	64.8	63.0	66.7	65.0	69.0
45° B	69.6	63.3	55.3	53.8	52.6	52.7	57.9
60° B	39.0	33.3	30.8	29.0	28.0	38.6	33.1
75° B	4.1	3.5	3.6	3.6	3.8	4.0	3.8
Cubic Feet Gas Used per Hr.	4.1	3.36	4.13	3.43	3.43	3.49	3.66
Mean Hemispherical Candle-power—							
Upper	70.4	66.3	59.8	53.4	58.1	58.6	61.1
Lower	68.5	60.8	53.4	50.5	52.9	52.8	56.5
Mean Spherical Candle-power	69.5	63.6	56.6	51.9	55.5	55.7	58.8
Gas Used per Mean Hemispherical Candle-power—							
Upper	.058	.051	.069	.064	.059	.059	.060
Lower	.060	.055	.077	.068	.065	.066	.065
Gas Used per Mean Spherical Candle-power	.059	.053	.073	.066	.062	.063	.062

a marked degree the illumination at points near by. This is shown by the curves in Figure 39, which establishes the fact that the mantle burner should be placed quite low to secure best illumination out as far as 80 feet from the lamp. Raising the lamp is accompanied by a diminution of illumination at all points within the distance range mentioned. These facts are more clearly shown in Figure 40, which gives both the illumination at 80 feet away from the lamp, and the mean normal illumination as a function of the pole-height. Increasing the height of the lamp

TABLE XV

FOR FIGURE 35, CLASS "C"—INCANDESCENT GAS MANTLES

Angle	Candle-power		
	No. 1	No. 2	Mean
75° A	34.7	33.0	33.8
60° A	42.0	43.3	42.7
45° A	59.8	61.6	60.9
30° A	70.6	71.5	71.0
15° A	78.5	84.2	81.3
Hor.	75.0	74.0	74.5
15° B	71.3	71.0	71.2
30° B	70.0	72.5	71.3
45° B	56.1	57.1	56.6
60° B	33.3	36.6	34.8
75° B	3.4	3.5	3.5
Cubic Feet Gas Used per Hour..	3.83	4.14	3.99
Mean Hemispherical Candle-power—			
Upper.....................	64.8	66.6	65.7
Lower.....................	58.0	59.1	58.6
Mean Spherical Candle-power...	61.4	62.9	62.2
Gas Used per Mean Hemispherical Candle-power—			
Upper.....................	.059	.062	.061
Lower.....................	.066	.070	.068
Gas Used per Mean Sperical Candle-power................	.062	.066	.064

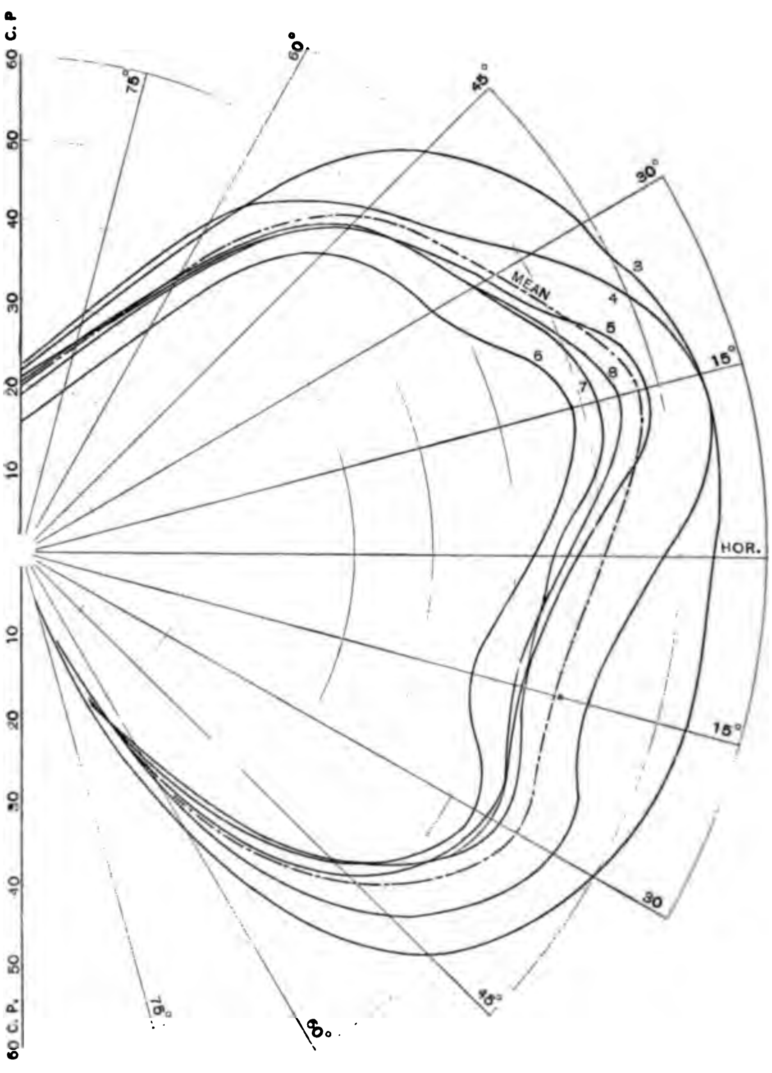


Fig. 34—Distribution of Candle-power about Class "B" Incandescent Gas Mantles

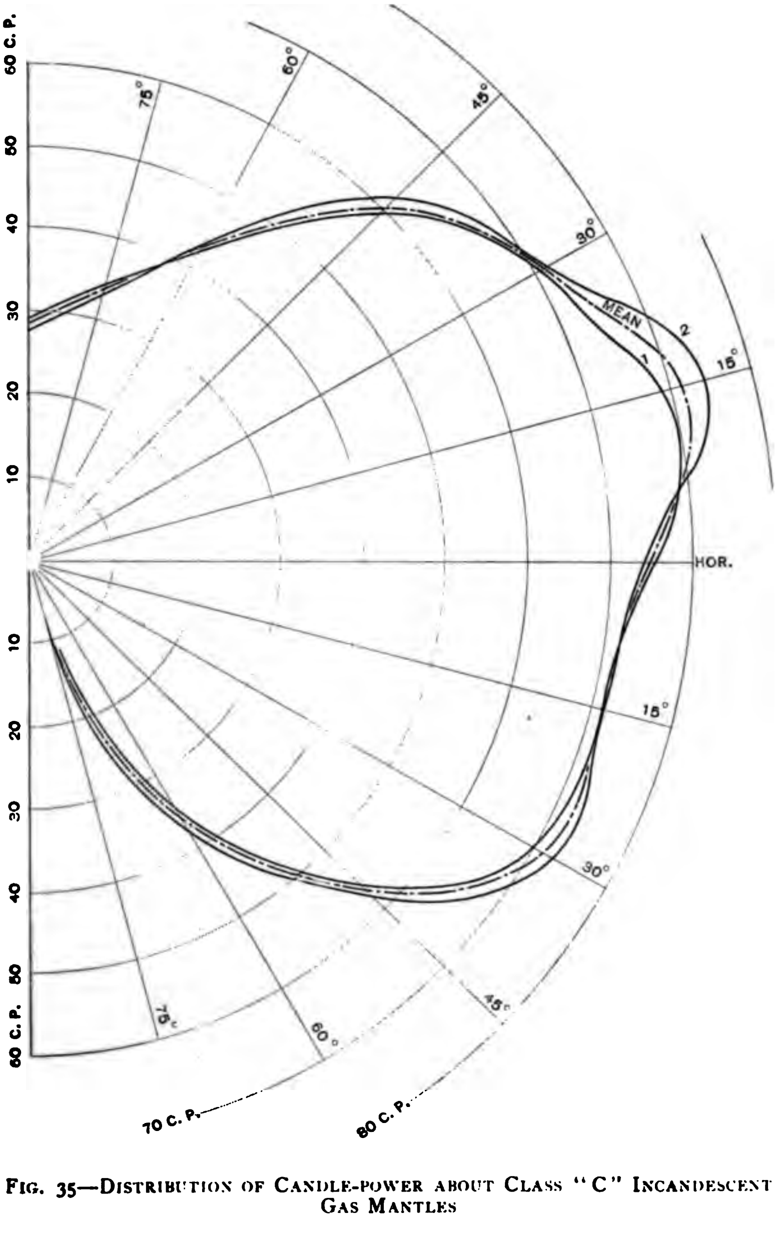


Fig. 35—Distribution of Candle-power about Class "C" Incandescent Gas Mantles

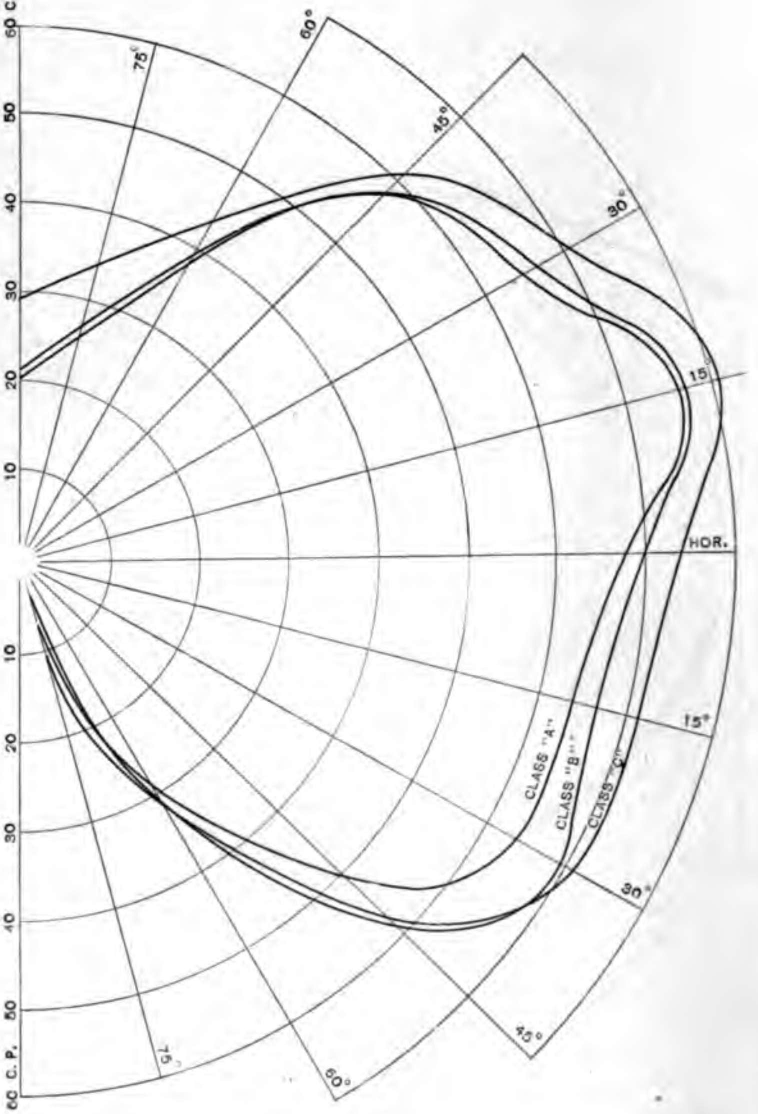


FIG. 36—MEAN DISTRIBUTION OF CANDLE-POWER ABOUT THE INCANDESCENT GAS MANTLES

from 8 to 20 feet diminishes the mean illumination over the range considered by nearly 25 per cent.

PHOTOMETRY OF THE OPEN GAS FLAME

Following are the results of a short series of tests of the candle-power and gas consumption of the ordinary open gas flame. An assortment of tips was secured from different dealers conveniently at hand. In seeking to test these, it was soon found that the nominal rating of the tip had scarcely any significance, either as regards the gas consumption or candle-

TABLE XVI

FOR FIGURE 37, INCANDESCENT GAS MANTLE WITH SHADES

Angle	Candle-power			
	Without Shade	Shade No. 1	Shade No. 2	Shade No. 3
75° A	26.30	41.20	54.12	39.70
60° A	42.85	29.45	36.78	37.80
45° A	58.65	18.22	30.00	35.30
30° A	68.35	33.76	23.50	37.17
15° A	78.60	71.15	47.26	40.65
Hor.	68.42	75.91	67.97	59.59
15° B	67.15	74.40	80.40	61.20
30° B	67.00	82.75	85.30	61.26
45° B	53.75	75.55	77.10	62.68
60° B	28.80	55.85	58.00	58.33
75° B	3.70	29.80	38.20	56.50
Cubic Feet Gas Used per Hour	3.75	3.75	3.75	3.75
Mean Hemispherical Candle-power—				
Upper	62.60	46.00	40.40	41.00
Lower	55.20	71.20	76.20	61.20
Mean Spherical Candle-power	58.90	58.60	58.30	51.10
Gas Used per Mean Hemispherical Candle-power—				
Upper	.060	.082	.093	.092
Lower	.068	.053	.049	.061
Gas Used per Mean Spherical Candle-power	.064	.064	.064	.073

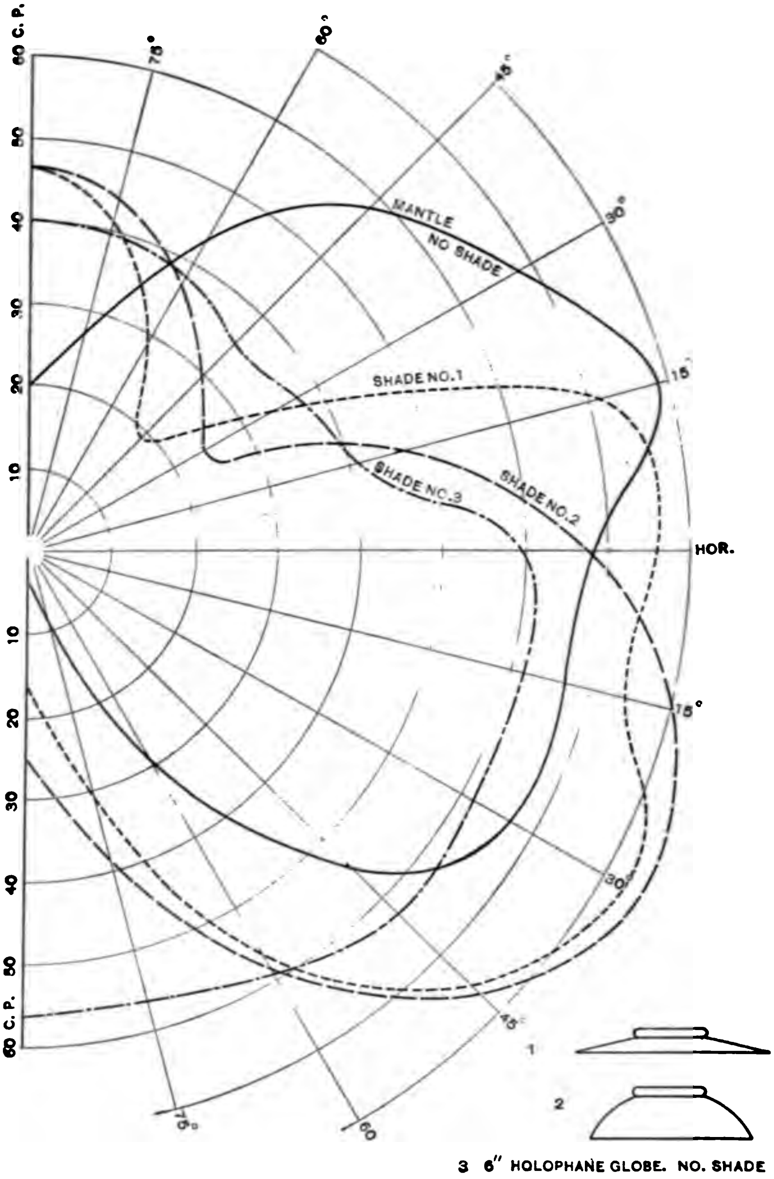


FIG. 37—DISTRIBUTION OF CANDLE-POWER ABOUT INCANDESCENT GAS MANTLES EQUIPPED WITH SHADES

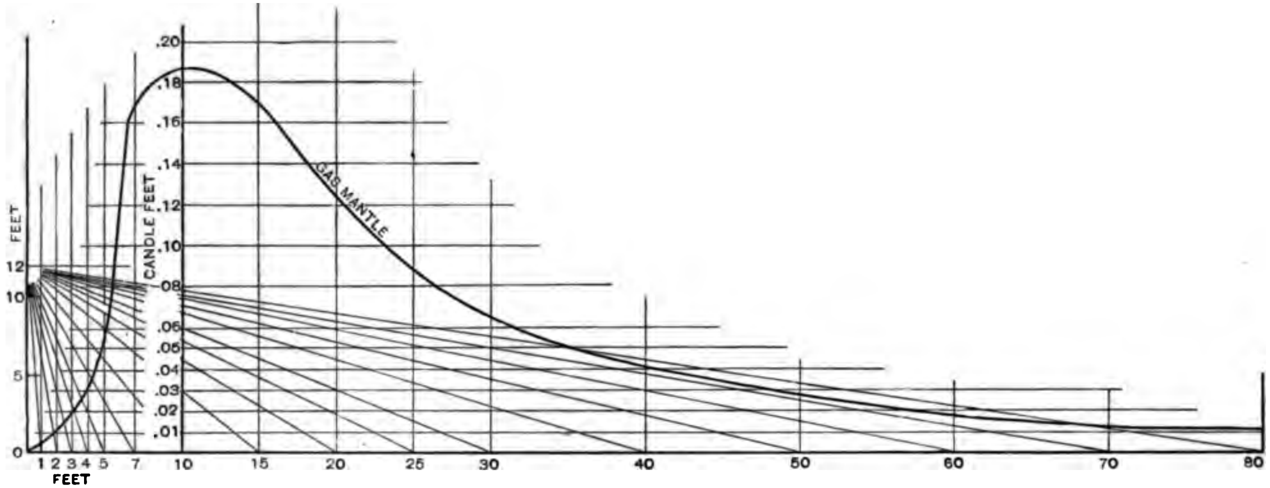

FEET
12
10
5
0
CANDLE FEET
.20
.18
.16
.14
.12
.10
.08
.06
.05
.04
.03
.02
.01
GAS MANTLE
1 2 3 4 5 7 10 15 20 25 30 40 50 60 70 80
FEET

FIG. 38

power. Table XVII gives the results of a number of tests on tips supposed to admit of a consumption of gas ranging from one to four cubic feet per hour, according to their marking. It will be seen that in some cases a one-foot tip gives as high a candle-power as a four-foot tip with no higher gas consumption. Apparently the classification adopted is a meaningless one. Table XVIII and Figure 41 give the complete results of a series of tests of candle-power and gas consumption of five tips operated under a gas pressure of 1.2 inches of water. In this table the distri-

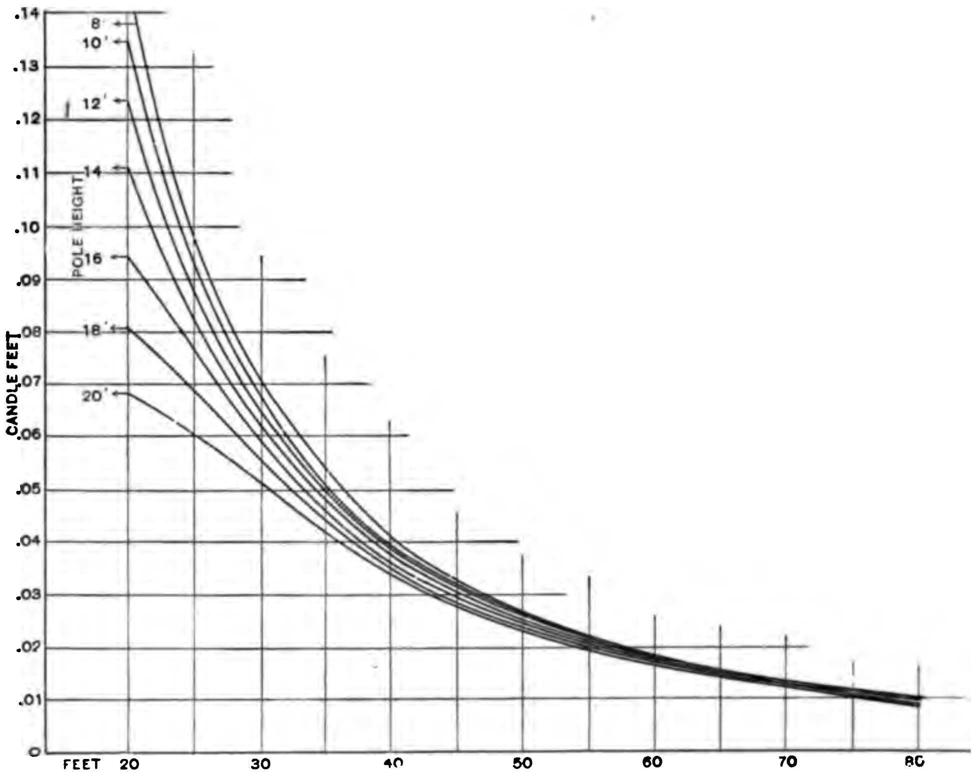


Fig. 39—Effect of Varying the Height of Incandescent Gas Mantles

bution of candle-power is given in two vertical planes, respectively parallel and normal to the broad side of the flame. These are referred to as 0 degree and 90 degrees, respectively. The mean of the two candle-power readings is also tabulated and forms the basis of the curves in Figure 41. Tips Nos. 2 and 5 represent extreme conditions found in the entire series of tests; 1, 3 and 4 represent more nearly average

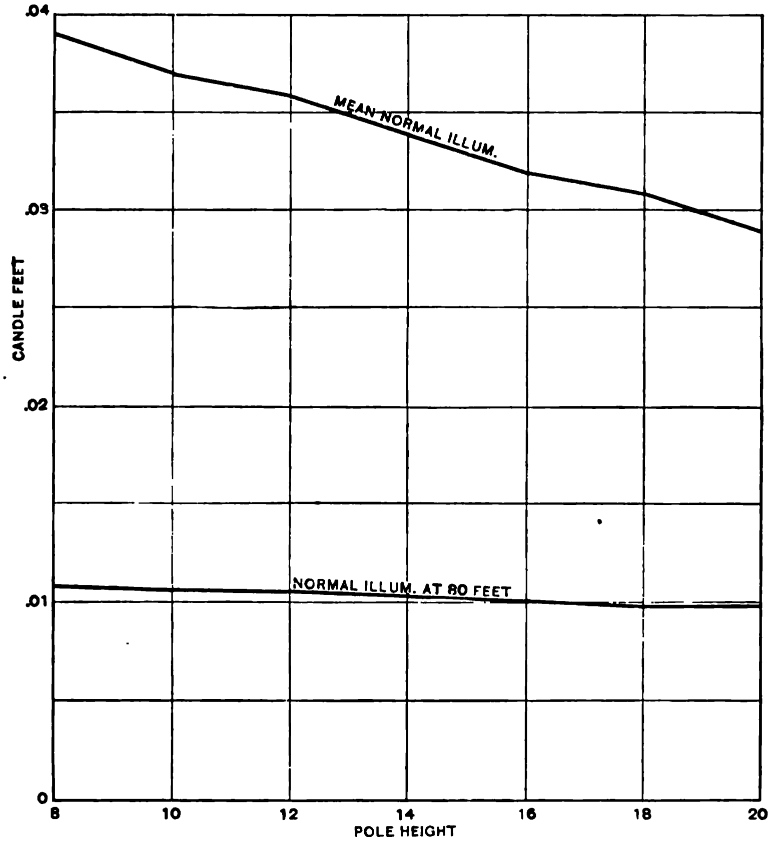


FIG. 40—EFFECT OF VARYING POLE HEIGHT ON MEAN ILLUMINATION 20 TO 80 FEET, AND ALSO ON ILLUMINATION AT 80 FEET, MANTLE GAS BURNER

conditions. From the curves, mean spherical candle-power was found in the usual way, and the gas consumption per candle-power tabulated. It is evident from these tests that the candle-power of gas, as found in ordinary commercial service, can be determined only by means of a very large number of tests.

TABLE XVII

SHOWING VARIATION IN SIZE OF ORIFICE OF OPEN-FLAME LAVA TIPS

Nominal Rating of Tip	Pressure of Gas in Inches of Water	Horizontal Candle-power Normal to Flame	Cubic Feet of Gas Used Per Hour
1 Cubic Foot...	1.2	18.50	6.15
	1.2	14.90	6.66
2 Cubic Feet ..	1.2	4.85	5.30
	1.2	3.60	3.33
3 Cubic Feet...	1.2	13.20	6.70
	1.0	22.50	8.30
	1.2	11.70	7.06
	1.2	9.45	6.70
	1.2	30.20	15.70
	1.3	29.20	16.15
4 Cubic Feet...	1.0	12.68	6.49
	1.0	18.80	8.20
	1.2	17.00	5.71
	1.2	16.10	8.06
	1.2	17.85	9.30
	1.2	9.10	6.90
	1.2	14.70	6.50

Chemical analyses of the gas used in this work show a very considerable variation in the composition of the gas at different times. An analysis made under the supervision of the department of chemistry of Purdue University on April 23, 1903, on which day a large number of candle-power measurements were made, gave the results shown in Table XIX.

TABLE XVIII

FOR FIGURE 41, OPEN GAS FLAME

PRESSURE 1.2" OF WATER

Angle	Candle-power						Candle-power								
	Tip No. 1			Tip No. 2			Tip No. 3			Tip No. 4			Tip No. 5		
	0°	90°	Mean 0° and 90°	0°	90°	Mean 0° and 90°	0°	90°	Mean 0° and 90°	0°	90°	Mean 0° and 90°	0°	90°	Mean 0° and 90°
75 A	15.77	19.30	17.54	6.02	6.70	6.36	13.38	10.73	12.06	20.85	20.35	20.60	30.6	33.6	32.1
60 A	13.38	17.27	15.33	6.90	5.23	6.07	10.40	10.80	10.60	15.12	17.68	16.40	26.2	29.4	27.8
45 A	15.37	14.40	14.89	6.27	5.07	5.67	9.82	10.52	10.17	14.90	16.43	15.67	26.8	29.4	28.1
30 A	13.90	14.45	14.18	5.96	6.49	6.23	11.21	10.86	11.04	17.02	19.15	18.09	26.4	29.8	28.1
15 A	15.00	16.09	15.55	6.16	6.03	6.10	11.01	10.92	10.97	19.10	21.00	20.05	26.3	31.3	28.3
Hor.	12.00	14.85	13.43	5.46	4.99	5.23	9.85	9.55	9.70	15.20	18.00	16.60	25.1	29.7	27.4
15 B	11.51	12.27	11.89	4.44	4.76	4.60	9.11	8.94	9.03	13.22	13.73	13.48	22.9	27.1	25.0
30 B	12.82	12.96	12.89	5.99	5.30	5.65	10.20	11.67	10.94	15.15	16.40	15.78	26.6	30.8	28.7
45 B	13.82	17.46	15.64	5.26	6.33	5.80	9.04	11.22	10.13	18.02	21.73	19.88	29.7	36.3	30.0
60 B	13.43	17.80	15 62	5.24	6.49	5.87	8.95	11.92	10.44	16.90	18.20	17.55	28.0	38.5	33.3
75 B	12.42	15.85	14.14	4.41	7.41	5.91	7.59	12.63	10.11	11.80	19.18	15.49	27.4	29.2	28.6
Cubic Feet Gas Used per Hour	5.75			3.64			4.45			6.20			9.7		
Mean Hemispherical Candle-power—															
Upper	15.00			6.00			10.67			17.96			28.60		
Lower	13.88			5.42			9.93			16.38			29.20		
Mean Spherical Candle-power.	14.44			5.71			10.30			17.17			28.90		
Cubic Feet Gas Used per Mean Hemispherical Candle-power—															
Upper	.384			.607			.417			.345			.339		
Lower	.414			.672			.448			.378			.332		
Cubic Feet Gas Used per Mean Spherical Candle-power	.399			.639			.432			.362			.336		

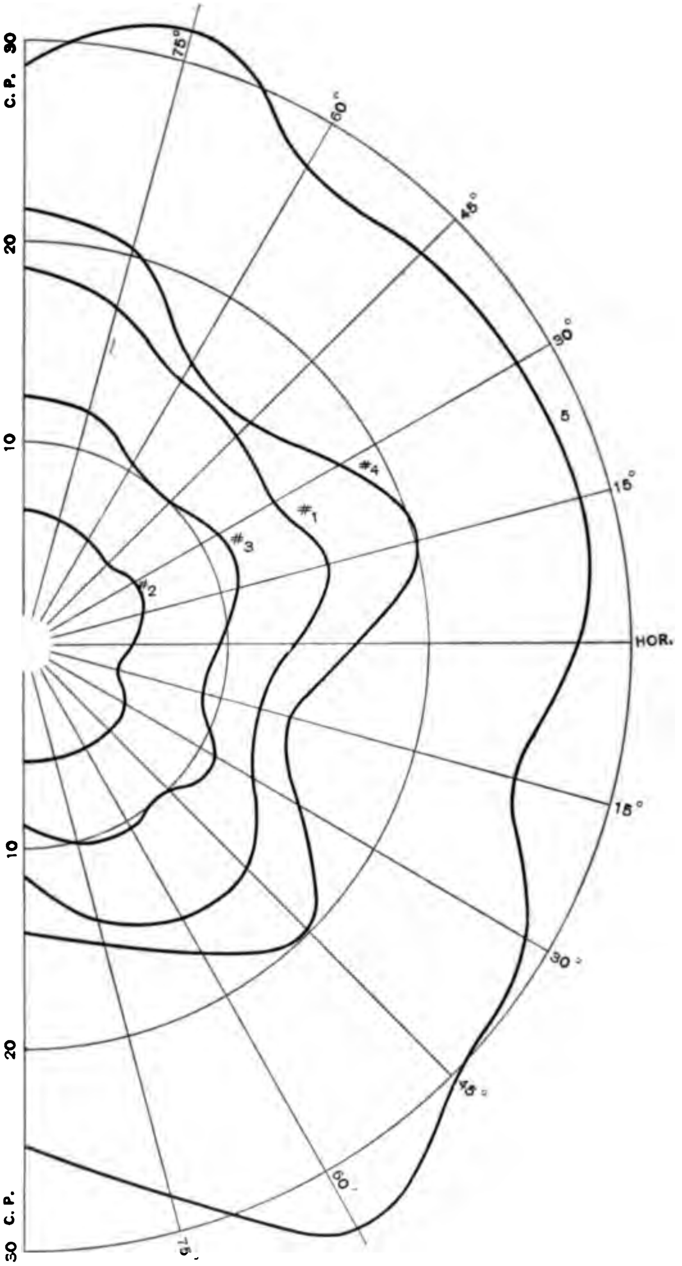


Fig. 41—Mean of Parallel and Normal Candle-power Distribution of Various Open Gas Flame

TABLE XIX

1.	Carbon Dioxide (and Hydrogen Sulphide)	5.0
2.	Free Oxygen	3.0
3.	Heavy Hydrocarbons	4.8
4.	Carbon Monoxide	5.0
5.	Methane	45.2
6.	Free Hydrogen	27.7
7.	Free Nitrogen (by difference)	9.3
	By volume	100.0

The gas is supposed to be a mixture of coal gas and water gas (enriched), but evidently contains a large quantity of natural gas.

Respectfully submitted,

C. P. MATTHEWS, Photometrist.

PAUL G. WINTER, } Assistants.
TERRY T. KING, }

After the reading of the report Professor Matthews gave an exhibition and description of the Matthews' integrating photometer.

THE PRESIDENT: Gentlemen, I think that instead of discussing these papers at this moment it will be better to have the report by Mr. Arthur Williams on Decorative and Sign Lighting. While it may not be a technical paper, it may be well to have all these papers on the subject of lighting at the same time.

(Mr. Williams presented the paper, which will be found in Appendix A.)

DISCUSSION

THE PRESIDENT: I am sure we shall find this report of Mr. Williams very instructive and interesting. It is gotten up in a most artistic manner and is worthy of careful preservation. The discussion on the paper of Professor Clifford, the report of the photometric committee and the report of Mr. Williams, is now open.

Professor Goldsborough: Mr. President and gentlemen: I have listened to Professor Clifford's paper and the reports of Professor Matthews and Mr. Williams with a great deal of interest. I think the suggestions that Professor Clifford has made and the results of which he has told us are going to be of the greatest value to the photometric committee. The committee consists of Mr. Doherty, Professor Matthews and myself. I have done so little of the committee work this year that I feel I can speak of it as an outsider. The entire credit of all the tests rests with Professor Matthews, who, with two assistants, has almost wrecked his health this year in his endeavor to bring before you results that will be of great value to the National Electric Light Association, especially when they are put in printed form and you have an opportunity of comparing the different sources of illumination studied—the arc, incandescent, Nernst, Welsbach and flat-flame gas lights. I doubt if the membership of the association really appreciates the work that Professor Matthews has done during the past four years. You perhaps do not know that photometry, through the work that this association has forwarded and through funds that it has supplied, has been very much advanced as a science over what it was before. The arc-light photometric methods developed by this association are now practically the standard for arc-light photometry; and I believe the instrument shown here to-day by Professor Matthews for use in studying and making quick tests on incandescent lamps will prove of the greatest value to the association and to the electrical fraternity at large.

As regards Mr. Williams' paper, I have been particularly pleased to see so many beautiful examples of electric lighting brought together in the way in which he has arranged them. The chairman of the committee on arc-light photometry, Mr. Doherty, suggested to me some time ago that it would be a nice thing if this association could be represented next year at the St. Louis exposition by a display of methods for decorative lighting, and after seeing this report by Mr. Williams it has occurred to me that Mr. Doherty's suggestion is well worthy your serious consideration, in view of the fact that it will call to the attention of the general public, in a most attractive way, the possibilities of lighting and of producing very fine effects on all occasions, whether of a social or a business nature.

Mr. Arthur Williams: I would ask Professor Clifford—speaking of the drop in voltage causing a drop in the candle-power of the Nernst lamp, not immediately recovered—to what extent that drop occurs, either in candles or percentages, and the full time required to bring the candle-power of the lamp to its normal value again?

PROFESSOR CLIFFORD: I have here curves showing the results. When the voltage was dropped 10 volts, held there for one minute and then restored to its normal value—which in the case in hand was 225 volts—the illumination changes due to the drop in voltage were in ratios about 5.4 to 4.9, and the lamp did not return to its normal illumination until after a period of about eight minutes. For a drop in voltage of five volts from 225 volts, held there for half a minute, the changes in the ratios were about 5.1 to 4.9, and the lamp did not return to normal candle-power for a period of about four minutes; so that in the matter of the change of five volts it is, roughly speaking, five minutes; for a change of 10 volts, something like 10 minutes. In both cases the Nernst lamp was compared with an incandescent, which was one of the standard lamps we have at the Institute of Technology, and the variation of its candle-power at the time was not a factor that need be considered.

THE PRESIDENT: I am sure we shall all be glad to hear from Mr. Hanks.

MR. M. W. HANKS (Pittsburg, Pa.): If the pressure is dropped on a Nernst lamp, of course the candle-power will also drop. On raising that pressure again the candle-power will of course go up, but not instantly, to its full value; but for all practical purposes, in general illumination, it does not come back. For standard work the voltage is not supposed to vary to a great extent, but when it does, means for control are introduced.

Dr. Nernst uses one of his glowers for standard work with splendid results. The glower in this case is operated in the free open air; that is to say, there is no heater near it. He uses an alcohol torch to bring the glower to conductivity. The light passes through a slit of such width as to eliminate the terminals of the glower. The ballast is of the regular standard type, or an ordinary resistance. The candle-power of the glower is kept steady by keeping the current constant rather than the pressure. Dr. Nernst has been using this glower standard for some time and has obtained splendid results; he likes it better than the incandescent lamp. The Nernst Lamp Company has not used this, however. It uses the incandescent lamp as a standard.

MR. R. W. ROLLINS (Hartford, Conn.): I would ask

Professor Clifford what the result is in rise of voltage; if it takes as long a time for the normal candle-power to be resumed in that case as in the other.

PROFESSOR CLIFFORD: I am sorry I can not give you any figures on the rise in voltage.

MR. ARTHUR WILLIAMS: I would ask Professor Clifford if the figures he gave, 5.4, 4.9, were in percentage or in candle-power. Some time ago I witnessed a test of the osmium lamp, in which, to show the durability of the filament, the pressure was increased from the normal of 50 volts to 70 or 80 volts, with a corresponding increase in candle-power; but after the pressure was restored to the normal the candle-power was much below the normal—to the extent of perhaps only 50 per cent of normal. It took some time for the candle-power to recover itself to the standard.

PROFESSOR CLIFFORD: The figures that I gave were the actual ratios of the Nernst to the standard incandescent; that is to say, the ratio before the change of voltage was 4.9, then after a drop in voltage the candle-power changed to 5.4, returning after eight minutes to its initial value; so the percentage change would be something like 12 per cent if expressed in that way.

PROFESSOR MATTHEWS: I have a chart that may be of interest. The Nernst lamp, starting at 210 volts, ran to 230 volts, 220 being normal, with practically a straight-line relation. The change in candle-power is very considerable. The change of one per cent in the voltage would make several per cent in candle-power; at 210 volts, 27 candle-power, at 230 volts it would go up to 59 candle-power: so the change is very great. Those having these measurements in charge made the tests at constant current rather than at constant voltage. They put through each glower four-tenths of an ampere uniformly and maintained it at such. We made a slight variation in the voltage and got much more uniform candle-power results at constant current than at constant voltage.

MR. RYAN: I am pleased to note that Professor Matthews' records on the watts per candle of the Nernst lamp compare favorably with results that I have obtained during the past year, except that my results show slightly higher efficiency under the various conditions. I should like to ask Professor Matthews what globes were used on the lamps when he obtained the results shown in the curves?

Professor Matthews: I presume you refer to the case of the arc-light curves. My impression is that the direct-current arc is with an opalescent inner globe and the alternating arc with, probably, an opalescent inner globe and a shade.

Mr. Ryan: Are those the curves published this year?

Professor Matthews: Yes.

Mr. Ryan: These are the same curves you reported on last year. I think a better understanding would have been obtained had you shown the Nernst lamp with opal globes, thus giving a better comparison, as it would then be under the same operating conditions. You have shown the Nernst lamp with a clear globe and the arc lamp with an opal globe, which, of course, favors the Nernst lamp.

I fear that I shall be obliged to take exception to the statements of Professor Matthews with regard to the whiteness of the Nernst light. When this lamp was first introduced the light was fairly white and of high efficiency, but had short life. The life has been considerably improved, and of course the efficiency has come down and the color has become more of an orange yellow. The color of the Nernst light to-day approximates very closely the incandescent light in quality. While it is possibly slightly whiter when new, it possesses a broken color effect or muddiness, due probably to a dark absorption band that exists in the green end of the spectrum. This lack of brilliancy or distinctness is noticeable in the reflections from all colors as well as from black and white. For some time I have been conducting investigations on the color effects of various lights with instruments designed especially for the purpose. One of these instruments—the lumichromoscope—is so arranged that four lights can fall simultaneously upon the material under examination. The candle-power of the lights is carefully measured and the intensity is brought to the same candle-foot value for each light, thus eliminating all error due to tint and shade or to the difference that would exist if the light falling upon the material from the different lamps were not all of the same intensity. We have remaining, therefore, a difference due purely to the wave composition of the various lights. I have here a few reproductions from the instruments in question. We will first consider the effects of four different lights, the arc, Nernst, Welsbach and incandescent—falling upon a piece of white material. The contrasts are so great as to be almost incredible; as we are not accustomed to seeing the color effects of different lights drawn to such a small focus, the difference appears much greater than we realize.

I might mention, however, that every precaution was taken by the artists in reproducing these effects to have them as nearly correct as possible. The investigation has been a long and expensive one, and we could not afford to deceive ourselves and make statements that would have to be corrected later on. In order to be on the safe side, I have given the Nernst, Welsbach and incandescent the benefit of the doubt; that is to say, these lights are a little further removed from white than the reproduced chart would lead one to believe. Later on, when the differences of light are more thoroughly understood, we can with safety put before the public reproductions of the charts that I am now showing you. Again referring to the white chart, it will be observed that the arc light is fairly white; the Nernst and incandescent are considerably removed from white and are not very different from each other. The Nernst has a slight advantage over the incandescent toward white, but possesses the broken color or muddy effect just referred to. You will observe this throughout all the charts. Of course the Welsbach is very far off toward green. The red chart appears to be the same for all the lamps except the Welsbach, which is considerably off toward the reddish orange. On the orange chart about the same relation exists as with the red, except that the Welsbach is down to an orange brown, the other three retaining to a considerable degree the proper color effect. On the yellow chart there is a wide difference in all the lights. The arc stands first, the incandescent second, and there appears to be a toss-up between the Welsbach and the Nernst. Here the Welsbach, Nernst and incandescent are far removed from their proper color, such as you obtain in daylight or under the arc. We next have a green. Here the Welsbach and arc are almost the same, the incandescent stands third, with the Nernst at the bottom of the list. Were it not for the broken color effect the Nernst would stand third.

I now show you the blue, in which the arc is the only one that shows anything like the daylight color of the material. We next have the violet, in which the same relation exists as in the blue; the Nernst and incandescent are almost identical, while the Welsbach is very far removed, and, in fact, the arc is the only light in which this material can be viewed to get the daylight effect.

In addition to the lumichromoscope there is another instrument, which we call the parachromoscope, which is virtually a multiple projector with specially ground lenses and diaphragms so that all lights can be brought to the same value at the *D'D* line by the aid of an integrating photometer. This insures accuracy in the color effects of the different lights.

MR. ARTHUR WILLIAMS: I ask if these samples were made with open flame and the absence of shades?

MR. RYAN: The arc lamp was an alternating-current, 6.6-ampere, inclosed arc, with opal globe and concentric diffuser. The Welsbach was also run under ordinary conditions; the Nernst had a ground-glass globe and the incandescent lamp had a clear bulb.

MR. HANKS: This color subject is certainly interesting. The color differences that I have been able to notice have not by any means been so marked as these shown. Possibly it is due to my eyes. I would ask how the different lights were brought to the same intensity, and also if the Nernst lamp was burning at the right efficiency; that is to say, did you have the right voltage? When making a test of this kind it is important that every lamp should be run under exactly normal conditions. I understand that there is an opal globe on the arc lamp and clear globes on the other lamps. We all know that there is an absorbing effect whenever you allow a light to pass through a colored glass, and if you are going to compare lights, is it fair to compare one light with a colored glass over it and the other lights bare?

MR. RYAN: The most practical way to compare the illumination of the various lights is to equip them as they would be equipped for regular service. The inclosed arc possesses a high percentage of violet light, which, of course, must be partly filtered out by the use of an opal globe, or otherwise. The test was made under this condition, and it is the condition under which the lamps operate. The Nernst lamp was run with the equipment sold with it; that is, ground-glass globe. The complete sets of tests and charts were made; one with the Nernst lamps running at normal voltage, and another set running at three volts high, thus giving it a slight advantage.

MR. ARTHUR WILLIAMS: I ask Mr. Ryan whether he found the alternating-current or the open arc the whiter?

MR. RYAN: The open-arc lamp gives a better light for matching colors than an inclosed-arc lamp, particularly if the latter is equipped with a clear-glass globe. By the proper selection of globes, the inclosed arc can be balanced for color so as to approximate average daylight. Of course, with the open arc we have the disadvantage of uneven distribution and concentration, which produces strong retinal fatigue and after-images, thus robbing all colors of their purity and hindering distinctness of vision and normal color perception.

PROFESSOR MATTHEWS: As to the matching of colors, is it not true that if you take a piece of fabric of any kind and cut it in two, the two parts will look alike when examined in any source of light whatever, no matter whether it be Welsbach, open gas or arc light, or anything else? Any source of light will serve to match two colors that are alike to begin with. For instance, a woman wants to buy a dress to wear at a reception. If the reception hall is illuminated by incandescent lamps she should go to a store illuminated by incandescent lamps and choose her dress, otherwise it will not look the same. The reason that fabrics look different is chiefly because we have changed the source of light. Two pieces cut from the same cloth will always look alike under the same light. We sometimes think that the proper thing is to have colors look by artificial light the same as they look by daylight. That is not necessarily true. To refer again to the matter of dress—if the dress is worn in the evening it should look in the evening as it looked to the woman when she bought it, or when she wears it it will not suit her.

THE PRESIDENT: The point brought out as to color matching is very interesting. Mr. Ryan illustrated that very cleverly at a meeting in this city some time ago, and although the conditions to-day are not such as to allow him to make the same illustrations, we should be pleased to hear from him on the subject.

MR. RYAN: What Professor Matthews says is true to a certain extent, and when we reach a point where stores will have separate departments for evening goods and day goods, evening goods can be selected under the lights under which they will be used. For instance, a store might have these rooms labeled "Goods to be worn under the Welsbach light," "Goods to be worn under the incandescent light," "Goods to be worn in daylight," etc. This, however, is not the condition existing to-day; one class of general illumination should be used, and we must therefore content ourselves with white light. If you buy colored material under a white light, you are not liable to be disappointed when you see it under a yellow light, but goods purchased under yellow light are sometimes very disappointing when seen in a white light.

It is not true that we can match goods under any kind of light. I should like to point out to you that you can not distinguish certain pale shades of yellow from each other, nor can you distinguish a very pale yellow from white under a yellow light, such as given by the incandescent or the Nernst lamps; nor is it possible readily to distinguish slight differences in green tints or a very pale green from white under a greenish light, such as the Welsbach. Very pale shades of green are capable of reflecting practically as much green light as white material. The white and pale green goods would therefore appear the same.

Furthermore, as a general thing various colors in a piece of material bear the same relation to each other for different intensities of light of the same color composition through certain limits, but the relations of one color to another undergo a complete change when examined under lights of different composition; therefore a combination of colors under the Nernst light would not appear the same in contrast as it would appear in daylight or under the arc light. The full value of these points must be realized before we can expect to reach a high plane of illuminating engineering.

Professor D. C. Jackson (Madison, Wis.): As is well known, it now and then becomes convenient, almost necessary, to operate Nernst lamps from low-frequency alternating current. It is almost impracticable to operate on low-frequency currents with arc lights, on account of the character of the light, and with some people an incandescent lamp on a circuit as low as 25 periods gives dissatisfaction on account of the sensitiveness of their eyes to the variation. The Nernst lamp, on account of its large heated mass, shows little variation of the illumination on a frequency as low as 25 periods a second. While our tests have not gone to the latter period, I imagine a frequency as low as 17.5 will show that the Nernst lamp has relatively little variation; this makes the Nernst lamp entirely practicable for use where it becomes convenient or necessary to operate on low frequencies, such as 25 periods per second, or even 17.5 periods, which are now becoming quite common in the large cities.

(The meeting adjourned until a quarter after two o'clock.)

SIXTH SESSION

President Ferguson called the meeting to order at twenty minutes after two o'clock, and announced the first order of business to be "Relative Advantages of Electrical and Mechanical Methods of Speed Control for General Power Service," by Mr. William Cooper, of Cincinnati, O.

Mr. Cooper read the following paper:

RELATIVE ADVANTAGES OF ELECTRICAL AND MECHANICAL METHODS OF VARIABLE SPEED CONTROL FOR GENERAL POWER SERVICE

DEFINITIONS

The expression, "variable speed control," is ordinarily understood to mean a system whereby a machine, or other piece of apparatus, can be operated at any one of a number of predetermined speeds, and when set to operate at any one of those speeds, it will continue to operate at that speed regardless of any change of load, or other operating condition. This definition is evidently too narrow, as there are numerous methods of variable speed control that, while not absolute, are sufficient for the purpose to which they are applied. It might be said that a series-wound, direct-current motor, operating a hoist, as on a crane, constitutes a method of variable speed control. The operator has absolute control of the speed and can operate at almost any speed within certain limits. However, any one position of the controlling handle does not necessarily give any particular speed, and any change of load changes the speed.

The expression, "variable speed control," is capable of three general definitions.

First—Where the speed is variable at the will of the operator, and remains constant when once adjusted, regardless of any change of load or other operating conditions.

Second—Where the speed is variable at the will of the operator, and may or may not remain constant, depending upon the conditions of operation.

Third—Where the speed is variable according to some prearranged plan, and is controlled automatically by some inherent property of the apparatus or of the driving power.

It is assumed that the prime moving force, or power, is constant and uniform in each and every case. That is, if a mechanical method of variable speed control be used, the shaft from which the power is taken rotates at a uniform velocity. If an electrical method of variable speed control be used, the energy is supplied at a uniform pressure and frequency. It is also assumed that the mechanism and apparatus used in connection with any method fulfills its functions properly, and does not, for instance, come under the second definition when intended to fulfill the requirements of the first. A mechanical method that depended upon friction for its action would do this if it should slip. A shunt-wound direct-current motor, with abnormal resistance in its armature circuit, would also do this.

CLASSIFICATION OF APPARATUS

In classifying the different kinds of apparatus in accordance with the above definitions, there are found to be some methods that operate under more than one definition. For instance, in the operation of direct-current, series-wound motors, the action, so far as the operator is concerned, is in accordance with the second definition, while, from the designer's standpoint, the action is in accordance with the third definition.

A general classification, however, would be that mechanical methods come within the first and third definitions; the electrical methods coming within these definitions and holding undisputed possession of the second.

In classifying the different kinds of mechanical and electrical apparatus, they fall under the different definitions about as follows:

First Definition—Where the speed is variable at the will of the operator and remains constant when once adjusted, regardless of any change of load. This definition contemplates manually-operated controlling mechanism. All methods of mechanical variable speed control, except those used in connection with automatic machinery, come within this definition.

The most common method of mechanical variable speed control is the use of the step-cone pulley. Next in point of common use is the use of change gears. Next, change gears in connection with step-cone pulleys. These arrangements are not only the most common, but they constitute probably ninety per cent of *all* the speed-changing apparatus in use at the present time. This fact, when considered in the light of their imperfections, certainly calls for some improvement. There are several devices that have been used to some extent, which are modifications of these step cones and change gears. In some the cones are used, but the steps have been eliminated, and two reversed truncated cones is the result. These are driven either by a belt passing around the two cones as an ordinary belt would be used, or by a loose belt around one of them, this belt being pressed between the two cones by suitable or unsuitable screws or levers. In either case the belt is moved lengthwise of the cones to vary the velocity ratio of the two cones. These arrangements are the natural outgrowth of the step-cone method, and have the advantage over the step cone of requiring much less time for adjustment and being able to get any speed within the range. As an outgrowth of the gear method, there are numerous devices using clutches, and other ways of getting them in and out of gear. Another method of belt drive consists in using a heavy belt, running in grooved pulleys, the relative diameters of which can be changed at will. Almost every conceivable arrangement of gears, belts and friction wheels have been used to accomplish this result, some of which have merit and utility, while others are little better than mechanical monstrosities.

The electrical methods that come within this definition are not nearly as numerous as the mechanical, and consist in the use of the sum total of one type of motor — the shunt-wound, direct-current motor. There are, however, several systems of operating the motor to give the desired result.

There are three ways of changing the speed of a direct-current motor.

First—By changing the volts impressed upon its armature.

Second—By changing the amount of magnetism of its field.

Third—By changing the number of conductors in series from brush to brush on its armature.

The impressed volts can be changed in two ways; by connecting the armature to circuits having different generated voltages, or by inserting a resistance, which may be varied, in the armature circuit.

The number of conductors in series on the armature can be changed in several ways. The simplest, and the only one that is used to any extent in practice, is to use two commutators with two separate windings on the armature. These two windings can be connected in series, and if they are identical, they may be also connected in parallel. The series arrangement gives practically one-half the speed of the parallel arrangement. The windings need not, however, have the same number of turns, in which case they may be operated in series for one speed and separately for two other higher speeds. If, for instance, the windings have a ratio of one to two, three speeds can be obtained, which will be to each other as one, two and three. This arrangement of two commutators is very useful where only a few motors are to be installed, but if the number exceeds five or possibly ten, there are other methods that are much simpler and more effective.

The amount of magnetism can be changed by changing the excitation, which is done in a shunt-wound motor by inserting resistance in the field circuit. In a series-wound motor this result can be accomplished by shunting or side-tracking a portion of the current by putting a resistance in parallel with the field windings.

Any of these methods of changing the speed of a shunt-wound, direct-current motor can be used, and come within the limits of the first definition, except that of inserting resistance in the armature circuit. It would then come under the second definition.

Second Definition—Where the speed is variable at the will of the operator, and may or may not remain constant.

There are, from the very nature of the case, no mechanical methods that come within this definition. There are, however, many electrical methods of great importance that answer this definition.

The series-wound, direct-current motor, that wonderful machine that holds the street-car and traction field against all comers, that does practically all of the crane and hoisting work, the *motor* of *motors* for hard work, comes under this definition. The shunt-wound, direct-current motor, when controlled by resistance in the armature circuit, also comes under this definition, as well as all direct-current motors that are combinations of series and shunt.

Third Definition—Where the speed is variable according to some prearranged plan, and is controlled automatically by some inherent property of the apparatus, or of the driving power.

There are many mechanical devices for producing this result, mostly in connection with automatic machinery of various kinds. The mechanical device may operate clutches, or friction, or may act upon the controller of the driving motor, if the apparatus be driven by an electric motor. These various arrangements are all in the nature of special apparatus, and do not directly enter into this comparison. There is, however, one electrical method that comes under this definition that is of great value in many kinds of work. The series-wound, direct-current motor has an inherent property of varying its speed in proportion to the amount of work it is called upon to do. This property is made use of in the design of motors for street-railway and traction purposes, and the motors will vary their speed in exact accordance with a prearranged plan. This makes it possible to use motors successfully on a road having a given profile, that would not do the work at all if it were not for this inherent regulation. For instance, suppose that it requires 50 horse-power to propel a given car at 30 miles per hour on a level track. Assume that the tractive effort required, under these conditions, be 10 pounds per ton, the car would weigh, approximately, sixty-three tons. If this car be required to mount a 10-per-cent grade, the tractive effort required will be 210 pounds per ton; 200 pounds for the grade and 10 pounds for friction, etc. Now, if a motor that fulfilled the first definition be used, it will be required to develop 1,050 horse-power to drive the car up the 10-per-cent grade. Assume that, due to the inherent regulation of the motor, the speed falls to 10 miles per hour, then the motor will only be required to develop approximately one-third the horse-power, or 350 horse-power. In practice this condition would not require a motor of 350 horse-power, normal rating, neither could one as small as 50 horse-power be used, but a mean somewhere between the two, depending upon what part of the total time the car would be mounting 10-per-cent grades. It is obvious, however, that there would be an enormous difference in size between the two motors.

APPLICATION

Each case where variable speeds are desirable must necessarily be considered by itself, as to whether the method to be adopted will come under the first, second or third definition.

The first definition covers the most general application, although there are many cases where absolute limitations of unvarying speed are not necessary, or where changing load or operating conditions can be met by manipulation of the controlling device. It is, however, necessary to use a method that will produce the result set forth in the first definition where constant speed is desired, and the torque, or turning moment required, changes to any considerable amount. Included in this class are practically all the so-called machine tools; such as engine lathes, drill presses, slotters, shapers, planers, boring mills, and all machines where the work is intermittent, or where the operation is started with the machine in motion. All wood-working machinery also comes within this class. Blowers and pumps, when operating with a constant discharge per revolution, and the discharge per unit of time is to be regulated by varying the speed, do not necessarily come in this class, and can be operated by any system, as the torque remains constant. Printing presses constitute another large class of machinery in which variable speeds are required, but in most cases, except in the larger sizes, the conditions are not very exacting, and can usually be met by methods as defined in the second definition.

COMPARISON OF ADVANTAGES AND DISADVANTAGES

It is not possible to compare two systems or methods unless both produce the identical result. If they do not produce the identical result they must be brought as near together as possible, and the value of the result taken into consideration as an advantage, or disadvantage, as the case may be.

Aside from, and not a direct function of the variable speed parts of the proposition, might be mentioned some of the advantages and disadvantages of electrical and mechanical drive in general. A mechanical drive, be it variable or not, in general means belts; belts mean dust and dirt deposited on walls and ceiling; dust and dirt on walls and ceiling mean a dark room. A man with the best of sight can see nothing in absolute darkness. The darker it is the less well he can see. The less well he can see the less work he can do. An electrically-driven machine causes none of this trouble. In the selection of the method of drive, too little attention is given to this point.

These are not the only advantages of independent electric drive. Some of the other advantages, outside of variable speed control, that are of great importance, are: no power being used when the machine is idle; ability to operate any machine in the establishment without operating any other, or any accessories of any kind except the generator; the small liability of a general shut-down due to the breaking of a belt or some trivial thing connected with the line shafting; the small liability of accidents to employees, as the greater portion of accidents in factories is caused from belts and shafting. However, all this is apart from the subject of variable speed control.

In comparing the electrical and mechanical methods strictly on a basis of speed variation, the comparison might be divided about as follows:

First—Total number of speeds within the range
Second—Ease of manipulation
Third—Cost of maintenance
Fourth—Total range of variation obtainable
Fifth—Time required to cover entire range
Sixth—Portability of machine
Seventh—Space occupied
Eighth—Cost of equipment
Ninth—Constancy of speed at any position of controlling mechanism
Tenth—Efficiency

In explanation of this classification, it might be said that the points are drawn out in what might seem to be useless detail, because they are all important, and must each be given due consideration. It will be noted that the point of efficiency is placed last, also that the cost of equipment is well toward the last. The number of speeds within the range of variation, or the amount of the change between two

steps, has been placed first in the list as being of greatest importance. This means the ability to get an exact speed that is best fitted for the work to be performed. If it is desirable to have any system of variable speed control, it is evident that it is for the purpose of getting different speeds. And if different speeds are required, they should be obtained with great exactness.

TOTAL NUMBER OF SPEEDS WITHIN THE RANGE

In comparing the different mechanical and electrical methods, it is found that there are two distinct classes of mechanical devices. One class is composed of those methods where a change from maximum to minimum is made gradually and gives an infinite number of speeds between the two extremes. Another class is where the changes are made in steps, as in the use of step-cone pulleys and change gears. The first class stands alone, as the *perfect speed-changing device.* Even an electric motor can not be made to give the same great number of different speeds, for the reason that a motor must be regulated by steps, although it is a very simple matter to make this number quite large and sufficient to meet the most exacting conditions. The step-cone pulleys, and change-gear arrangements, when carried to the point of yielding the same number of different speeds, become very complicated. While it is entirely possible to get a change in this manner of 10 per cent per step, the complications resulting from the mass of gears, and multiplication of steps on the cone pulley, would not be permissible, to say nothing of the time lost in making the changes. As a result of years of practice, this system has developed into an arrangement where the changes are approximately 50 per

cent per step; that is to say, each increment of increase is 50 per cent; often as much as 100 per cent. It is obvious that such an arrangement must be very wasteful of time, as it will often occur that the work in hand will not quite permit of a certain combination, and must necessarily be run at the next lower speed, consuming consequently 50 per cent to 100 per cent more time for a given operation, than would otherwise be required.

There is also another fact that should not be lost sight of in this connection. The range of speeds given by the step cones on a great many machines is not consistent with the ratio of the back gearing used. That is to say, it is frequently found that the difference between the lowest speed with the back gears out and the highest speed with the back gears in, is very much greater than the difference between two cone speeds. Some machines have as much as three-to-one variation in speed between these two conditions. As a case in hand, might be mentioned a comparatively small-sized boring mill, made by a prominent manufacturer, in which the back-gear ratio was twelve and one-half to one. Assuming that the cone speeds were consistent with this back-gear ratio, the average difference in speeds throughout the entire range would be about one and nine-tenths to one, the machine being equipped with a four-step cone. This is certainly a very crude solution of the problem of variable speed control, and yet there are thousands of machines no better than this in everyday operation in manufacturing establishments, where they are supposed to be running things to the limit, and on the most economical basis. The crudest kind of an apparatus that would sub-divide the speeds of such a machine would certainly produce superior results.

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Any system of variable speeds to be applicable, and to cover the ordinary working conditions, must be able to cover all possible speeds within the range of the machine to within a very few per cent.

EASE OF MANIPULATION

This feature of the apparatus used should be well considered. If the device requires some considerable manual effort on the part of the operator to effect the changes, there is just that much less liability of a change being made when the nature of the work really demands it. A great deal can be sacrificed in other directions to relieve the operator of all possible manual effort, not alone because of the natural inclination of a man to do as little manual work as possible, for, as Emerson said, "Mankind is as lazy as he dare to be," but because in most cases where a device of this nature is used, the operator is paid for his skill and the use of his brains and not for his manual effort. A great many mechanical devices are objectionable on this account. It also, as a rule, follows that a device that requires any considerable amount of effort to operate will also consume considerable time. All of that class of devices that use change-gears and step-cone pulleys require more or less manual effort, especially where friction clutches are used to throw them in and out of gear. The electrical method probably offers the easiest operation, as a simple movement of the controller handle not only gives the different speeds, but also stops, starts and reverses the motion of the machine.

COST OF MAINTENANCE

This is a point that should also be given due consideration. Generally speaking, the piece of apparatus that has the smallest number of moving parts will be the most durable, and an effort should be made to eliminate all parts possible. Most mechanical speed-changing devices that fulfill the requirements and are worthy of the name of speed-changing devices are quite complicated, and embody in their structure a great many parts that are subject to a great deal of wear. The modern electric motor, without doubt, requires less attention for repairs than any other piece of apparatus that would fulfill the same functions. There are many mechanical devices designed to be used as variable speed changers that certainly carry the stamp of trouble on their faces. The use of such devices should be avoided. However, in justice to the mechanical devices used for this purpose, it is but fair to state that many electrical systems are no better. The prime object to be kept in view, when considered from the standpoint of durability and permanence, must be simplicity.

TOTAL RANGE OF VARIATION OBTAINABLE

In considering the installation of a method of variable speed control, this is one of the first problems to be solved. The machine to which the device is to be applied calls for certain maximum and minimum speeds, these maximum and minimum speeds, of course, being determined by the work that the machine is intended to perform. There are many machines where a system of variable speeds could be applied to great advantage that are now being operated at a constant and uniform speed. With the exception of such machines as are operated day in and day out on one particular and specific operation, almost any machine used in manufacturing, or in an industry of any kind, could be worked to advantage at different speeds.

For instance, the simple operation of calendering paper can be done to much greater advantage if the speed can be adjusted to the quality of the paper being handled. In this case a comparatively narrow range of speed would be required. In the operation of printing presses this condition exists. In a great many machines used in the manufacture of boots and shoes the same condition exists. In fact, there are thousands of cases where a method of variable speed control could be used at a profit, that are now considered good enough when operated at uniform speed.

The class of machinery that probably requires the widest range of variable speed, comprises the so-called machine tools; especially is this true of that class of machine tools that operate upon cylindrical work. In this class of work, the piece being operated upon is usually rotated, and as a very small proportion of this work has but one diameter on each piece, there must of necessity be provided some way of changing the speed of rotation in order to maintain a constant maximum cutting speed. This condition is arrived at in ordinary machine-shop practice on this class of work by using certain arrangements of change gears and step-cone pulleys. It is obvious that a combination of gearing and step-cone pulleys is used to keep the speed of the driving belt within certain limits. For instance, if a given machine has a four-step cone and one set of back gears, the same result could be accomplished by an eight-step cone, but the driving belt would have a maximum and a minimum speed, either one or the other of which might be prohibitive. In all the different methods of variable speed control, when applied to machine tools, recourse is generally had to some arrangement of gearing. An electric motor would be out of all proportion if designed to cover the wide range of speed variation called for in an ordinary engine lathe.

The same is true of mechanical methods, other than those using different trains of gearing. The total speed range of that class of machine tools that operate on cylindrical work should not be less than sixty to one, although in some special cases a very much narrower range than this will suffice. In equipping such a machine with an electrical method of variable speed control, if an attempt is made to cover this entire range inherently within the motor, the motor would be abnormally large and expensive. However, it is possible to do this. The use, however, of one set of gears in connection with the machine that requires a total range of sixty to one, simplifies the proposition very materially.

In the class of machine-shop tools in which the work has a constant relative motion to the cutting tool—as in planers, slotters and this class of machines—and speed variation is only required for the different kinds of material, the total range can be easily covered by the mechanical devices in use, or by the inherent speed regulation of an electric motor.

If the range of variation of the method employed necessitates the use of one set of back gears in order to make the method practically operative, the question will naturally arise, why not use two or more sets and still further simplify the speed-changing device, or reduce the size of the variable-speed motor. Duplicating the gearing indefinitely until variations in speed are entirely taken care of in the gearing, brings us to a mechanical speed-changing device pure and simple, in which the changes are all brought about by different combinations of gearing. The use of one pair of gears is objectionable from the point of time consumed in the manipulation, and also from the wear and tear. Consequently, a multiplication of gearing only makes these objections more pronounced.

TIME REQUIRED TO COVER THE ENTIRE RANGE

This characteristic is very closely connected with the subject, "Ease of Manipulation." Some devices, however, are handled very easily, but require a considerable amount of time to make the changes. Most notable of these are the arrangements of gears where a clutch is opened and closed each time a change is made from one speed to another higher or lower, and this operation has to be performed as many times as there are changes in the total range. The point of time required in the manipulation of the speed-changing device is worthy of serious consideration. As pointed out under the heading of "Ease of Manipulation," the electrical system of control can be operated very much more quickly than any of the mechanical systems.

PORTABILITY OF MACHINE

This heading is a little misleading, as it is not only intended to cover machines that are portable or movable, but to include the general characteristic of being, as it were, disconnected from all other machinery. Considered from this standpoint, there is no comparison between the electrically-driven machine and the mechanically-driven one. The advantages are all with the electrically-driven machine.

The advantage of portability, of course, can be obtained and not use the electric motor for the variable speed control; that is, a constant-speed motor may be used and the changes in speed of the machine obtained by mechanical means, either gearing or other arrangements. However, it does not seem that such an arrangement is worthy of consideration. If an electric motor is used to drive any given machine, the cost of a motor that will have inherent in it the ability to produce the variable speeds required, is so little in addition to the cost of a constant-speed motor, that the installation of a mechanical variable-speed apparatus in addition to the constant-speed motor need not be considered. Of course, as already pointed out, it is impracticable, and well-nigh impossible, to get the entire speed range from the motor itself, but if a motor is used it should be made to give the fine gradations necessary, and through a considerable range.

The advantages of having any machine entirely independent, as it were, of its driving power, are too well known to need further illustration. It enables one to locate the machines in the best possible position for the facility of handling material, and if at any time the process is changed, the machinery can be readily changed to suit. The machines can be placed under traveling cranes in such a position that they can be served to the best possible advantage. It often occurs that some simple operation is required on a large amount of material, in which case the machines can be taken bodily to the work at a very much less expenditure of time and labor than would be required to bring the material to the machine.

The advantages gained by the portability of machines makes a direct comparison with any mechanical system of drive very difficult, as the mechanical system can not be said to embody this feature in the slightest degree.

SPACE OCCUPIED

The space occupied by electrically-driven machinery is always very much less than that occupied by mechanically-driven machinery. The motor can usually be mounted in such a position that practically no available operating space is used, while in almost every instance where mechanical drive is employed, the line shafting, countershafting and variable-speed-controlling mechanism occupy space that can be used to great advantage in handling material. That is, the space overhead is nearly as valuable as the space on the floor, for in the modern method of handling material the overhead traveling crane must occupy this space. This is a feature of individual electrically-driven machinery that enhances the value of the machine as a producer, probably as much as any other one feature.

COST OF EQUIPMENT

Although this point is placed well toward the last of the list of points to be considered in the comparison of mechanical and electrical methods of variable speed control, it is not by any means the last thing that the purchaser considers. In equipping a new plant or factory of any kind, a careful summation of all the costs in connection with the different systems employed will show that there is but little actual difference in the total first cost. In the individual application of motors to machinery, the cost of the motor and its accessories increases the cost of the individual machine very materially, but when the decreased cost of the building, owing to the absence of heavy lines of shafting, is taken into consideration, a very material offset is found. When compared with the actual cost of the installations of the mechanical speed-controlling mechanism, a still further offset in the cost is found.

In equipping old machinery with variable-speed-controlling devices, the proposition is somewhat different. The investment for transmitting power to the machinery has been made, the building has been constructed with a view to carrying the necessary line shafting, countershafting, etc., and this has all been installed. The proposition of a very much increased investment at once confronts the would-be purchaser, if he considers the installation of individual electric drive. He naturally turns his attention to the mechanical methods of variable speed control, and finds that he can install some of these systems at a very much less cost. In justice to the mechanical systems of variable speed control *that fulfill the requirements*, it must be said that under these conditions they certainly accomplish the results sought. .However, considerable expense is involved in the installation of such a device, and usually an increased cost of operation. These points should be given due consideration in comparison with the radical changes to individual electrical drive. The electric motor is to most people operating manufacturing plants and establishments of different kinds, a rather mysterious thing. This, coupled with the poor behavior of some motors that they may have come in contact with, has caused them no little apprehension and doubt as to the capabilities and durability of the modern electric motor. This condition of affairs has made it a good deal in the nature of "buying a pig in a bag," to the average purchaser, and it must be admitted that in a good many cases this was actually the fact. The modern electric motor, however, is not a toy, but has developed into an actual machine, and from a comparatively weak infant is now a sturdy man, to be depended upon for hard work and faithful service; and although the cost may seem considerable when compared with some other systems of operation, when all the facts are taken into consideration, the first cost of a new installation is not materially different.

CONSTANCY OF SPEED AT ANY POSITION OF CONTROLLING MECHANISM

It is assumed that any device used as a method of variable speed control shall fulfill its functions properly.

The only mechanical methods of variable speed control that are really worthy of consideration are those in which any number of different speeds may be obtained, and, from the very nature of the case, some form of friction drive must be used. This may be either in the form of a belt drive, or of the many kinds of friction-wheel arrangements. These friction arrangements are at best not thoroughly reliable and consume considerable power in their operation. On the other hand, an electric motor, when used as a variable-speed device, has one drawback; the speed is not absolutely constant, due to the lost volts in the armature, by virtue of the ohmic resistance. This characteristic, when the motor is used on very low voltages, makes the inherent regulation from no load to full load of the motor in some cases very poor. This point should be well guarded against in the design of motors for this service. A motor used to operate an engine lathe, for instance, whose speed will drop twenty-five or fifty per cent when the tool is applied to the work, will not give satisfactory results. Neither will a mechanical device that has a propensity for slipping, whenever called upon to do hard work, give satisfactory results. Any device used for the purpose of variable speed control should be able to drive the machine to which it is applied under any and all conditions, from the very slightest to the very heaviest work that it may be called upon to do, without showing a variation in speed of more than a few per cent. A great many arrangements for variable speed control have proven entirely unsatisfactory for this reason. Many attempts have been made to operate machine tools with motors where the speed regulation was obtained by resistance placed in the armature circuit. These, without exception, have proven failures. There are some instances, however, where a small amount of resistance is used in the armature circuit in connection with multi-voltage systems of control that have not proven failures. The results obtained, however, are not what they should be, although the general result of these applications may have been satisfactory. This is a vital point in the operation of any variable-speed-controlling system, and any characteristic of the apparatus used that is liable to produce an unsteady motion should be carefully avoided.

EFFICIENCY

The comparison of the efficiencies of the various mechanical methods of speed control with the various systems of electrical speed control is not altogether favorable to the mechanical system. An electric system, even when using very small motors individually applied to very small machinery, will show a better efficiency from the prime mover to the work than any mechanical system of power distribution, except in cases where the number of machines driven is very small and the power from the prime mover is applied directly to the machine. Of course, due consideration must be given to the size and type of the motor installed, when using the electric system of power distribution, due regard being had for the average working conditions. The reason that the electric systems of power distribution, in case of individual motor application, show higher total efficiencies, is that when no work is being done, no power is consumed; while with the mechanical system of power distribution, there is a friction load, which is a certain amount when no work is being done, and increases somewhat as the load increases. It is not at all uncommon for the friction load of a manufacturing establishment to be 50 per cent of the maximum load on the prime mover. In an electric system of power distribution, the conditions would be very bad indeed if the power factor were not higher than this.

CONCLUSION

In the installation of a new manufacturing plant in which machinery will be installed that will require to be operated at varying speeds, the different methods employed for producing these results should be considered in about the following order:

First—What system will assist in yielding a maximum output from the machinery installed.

Second—The comparative costs of the different methods installed.

Mr. L. R. Pomeroy, in a paper read before the Central Railway Club, in Buffalo, November 14th, last, quoted a celebrated authority (without naming the authority), as follows: "Where we have to decide whether we shall install one large motor or a number of small ones, I would give preference to the small motors down to a limit of five horse-power for light machines, and ten horse-power for heavy machines; this for cases in which the problem is one of distribution only. Where the introduction of motors would have any effect on the product, I would dismiss entirely the question of power and decide solely with regard to the convenience of operation afforded, and would not hesitate to put in the very smallest motors mounted upon any kind of machinery, notwithstanding their greater cost and lower efficiency, if they even to but a slight degree increase the product of the labor of the shop. Gains in this direction cause other gains to sink into insignificance."

In this comparison, the authority quoted is only comparing small motors with large ones in the point of efficiency. The point of this remark is that any gain in the increase of the production of the labor of the plant is of more importance than any other consideration. It is a very simple matter to calculate how much the production will have to be increased to offset a given investment. When this calculation is made it is easily seen that a very slight increase in the production will offset a very large investment.

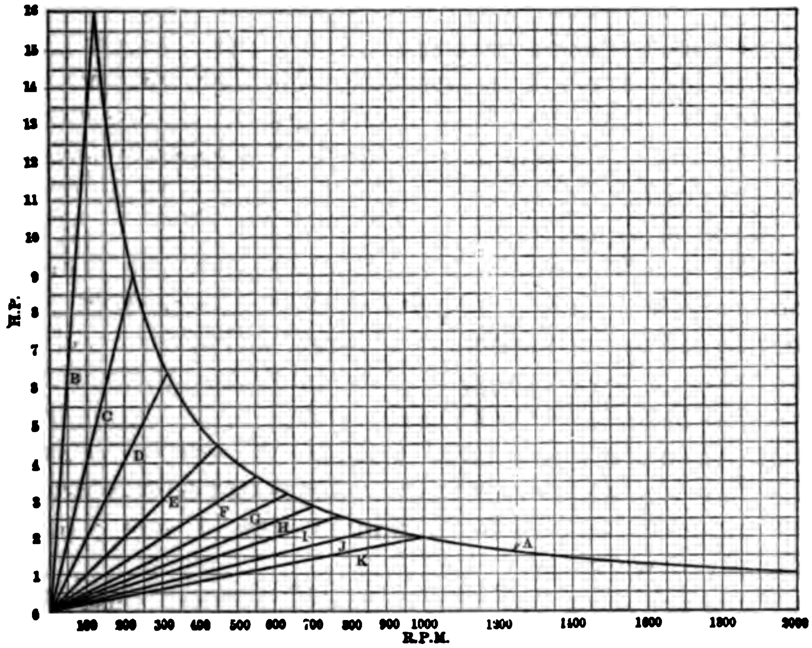
When an attempt is made, however, to make an exact determination of the increase in the production, due to the installation of any improved apparatus, it is found to be a very difficult thing to do. The introduction of a traveling crane into a plant handling even comparatively light material, is always accompanied by an increase in the output, although the labor item may not be very materially reduced. The reason for this is not hard to find. Although the same number of men may be employed on a given floor space, the amount of material that these men can handle is increased for the simple reason that only a certain amount of crowding of workmen or machinery into a given space is permissible. The same thing is true of the introduction of apparatus that will hasten the production of the machines themselves.

Usually, in the consideration of the advisability of installing any certain method of operation, the questions are considered in the reverse order to that given above. The first question is, how much will it cost, when really the first question ought to be, how much will it increase the output.

Considered purely from the standpoint of variable speed control, some of the mechanical systems of variable speed control offer the only *perfect system*. In this they have the advantage, but their accompanying disadvantages very materially offset this advantage in comparison with some electrical systems.

Great care should be exercised in the selection of motors for different machines, to determine whether the horse-power required is practically constant or varies with the speed. In most machines of a reciprocating action—slotters, shapers, planers, etc.—the power required varies with the speed, as the power is consumed in the reversals of the machines, and not in the actual work being done. In cases of this kind, the motor will be called upon to do its maximum work at the maximum speed of the machine, while in the case of machines in which the work performed is constant, irrespective of the actual speed of the machine itself, the power required to drive it will be practically constant throughout the entire range of variation. In machine-shop tools, such as lathes, boring mills, milling machines, etc., this condition exists.

There are two methods of varying the speed of a direct-current electric motor that are in common use. There are other methods, but none of them is as simple and effective as these two. The two methods referred to are that of varying the volts impressed upon the armature of the motor, and varying the amount of magnetism in its field. These two methods can be used to great advantage in conjunction. When the range of different voltages impressed upon the armature of the motor and the range through which its speed is changed by changing the amount of magnetism in its field, are properly proportioned, the minimum-sized motor for the total speed variation is obtained. This can readily be seen from the curve attached.



Horse-Power Curve, Multiple Voltage and Field Regulation

In explanation of the use of the curve in any given instance: if the speed range has been determined—as well as the maximum and minimum speeds—the full field full-speed voltage can be ascertained from the curve as follows: Locate on the curve *A* the point corresponding to the maximum speed which it is desired to operate. Trace to the left from this point on the scale of ordinants and read the horse-power. This horse-power may not be the actual horse-power in any given case, but it can be assumed as proportional to the actual horse-power required. Again trace from the minimum speed, which it is desired to operate, vertically, until the horizontal line which represents the same horse-power that was determined from the curve *A* is reached. Through this point draw a straight line from the origin *O*, intersecting the curve *A*. From this point of intersection trace downward to the base line and the full voltage, full field speed of the motor will be found.

To get the minimum speed we must use some other method than field control, because the field is already up to its maximum strength, and we therefore introduce a lower voltage. The ratio that this lower voltage bears to the normal voltage is the same as that which the lower speed bears to the normal speed. By this combination of multi-voltages and field-control we are able to get the minimum size of motor for the given work.

The following few simple rules may be of use in determining the relative size of motors for constant horse-power application:

First—The total range of speed, using both variable voltage and field regulation, will be as the square of the range of voltages.

Second—Change of horse-power will be directly proportional to change of voltage on armature, field being constant.

Third—Change of horse-power by change of field strength will be inversely proportional to change in speed, voltage on armature remaining constant.

Fourth—Relative size of motor, as referred to the maximum speed, will be directly proportional to its speed variation when using variable voltages.

Fifth—The relative size of motor, as referred to the maximum speed, will be as the square of the speed variation when using field regulation.

DISCUSSION

Mr. Cooper: There is a great use for motors in small manufacturing plants. There are many places where they could use motors to great advantage, and they only require a few horse-power; and when they get the cost of operating these motors from the central-station plant they fancy they can not use the motor, and the small gas engines are finding quite a field. It seems to me that from an engineering standpoint there is no reason why the electrical concerns should let the gas-engine people get away from them in this power matter. There has been a great deal of discussion at this meeting about the day load, and it seems to me that in this line the power matter is worthy of serious consideration.

The President: We should like to hear from any other gentleman on this subject.

Mr. E. V. Lloyd (Chicago): In Chicago, the cost of driving machinery by gas engines in comparison with electric-motor drive is approximately the same, so far as my observation goes. The advantage in favor of the electric motor is in the cost of maintenance, as the repairs to a gas engine increase very rapidly after it has been in operation a year or two.

The claim has been made that the gas engines require little or no attention. The experience of the Chicago Edison Company's customers points to a different condition of affairs. We take out a great many gas engines every year and install electric motors in their stead. I have yet to know of a case where the customer has returned to the gas engine after using electric drive.

In connection with the use of variable-speed motors by customers of the central-station company, we are limited at present to two voltages and must use a motor designed to operate on the three-wire system with a wide variation in speed. A motor constructed with specially wound fields used in con-

The advantages of the three-wire Edison distribution, with special motor, are as follows:

First—Simplicity. A 250-volt, direct-current generator, with neutral brought out from collector rings, and balancing coils, provides for the 125-volt potential, while in the multi-voltage system a complicated motor-generator set having a total capacity approaching the main generator must be furnished. The Edison three-wire distribution system is common for light and power, and, being a very nearly balanced load, nearly all the power is delivered at 250 volts with small losses. With the multi-voltage system four or five conductors are necessary for power circuit and two or three conductors for the lighting circuit, and the losses are large. These carried to each machine make not only a complicated but an expensive distribution system.

Second—The first cost of the generator, the special motors, controllers and distribution system, will generally be less than the generators, multi-voltage compensators, motors, controllers and distribution system.

Third—Efficiency is considerably in favor of the Edison three-wire system.

MR. GILLE: I would ask if the reference made by Mr. Lyman to putting a variable-speed motor on the Edison three-wire system refers to the network in cities. We have tried it, and unless you have neutral feeders of the capacity of the outside feeders you are liable to get into trouble. I should not like the impression to spread that the association would favor the putting of variable-speed motors on the network, because I do not think it is possible.

MR. LLOYD: We have a large number of motors operating on two voltages in Chicago, such as printing presses, fans, air compressors and ammonia compressors. The majority of these motors are under 15 horse-power, but we have one of 80 horse-power operating on two voltages. I would say, however, that this large motor is near a substation where we have installed a balancing set to even up the pressure.

MR. COOPER: I would ask Mr. Lyman with reference to large installations of variable-speed motors that have signally failed with regard to their functions. I was formerly connected with the Bullock company, and it has installed a great many multiple-voltage systems, as has also the Crocker-Wheeler company. I do not think that any of the installations have signally failed in any individual case. Of course there are always instances where things do not work so perfectly as they might, but the fact that they are rapidly increasing the number of these motors installed seems to me sufficient evidence that they have not failed.

Regarding the point Mr. Lyman also made about the balancing effect for multi-voltage circuits—the arrangement of a balancing set is essentially this: We have a generator of any suitable capacity, and this multi-voltage system can be worked on any number of wires we like, greater than two; three wires with equal voltages or three wires with different voltages between the mains, or four, or five, or more wires. The system to which the gentleman referred is probably the four-wire system.

(Mr. Cooper then drew a chart illustrating how motors should be operated on a four-wire system.)

Mr. Arthur Williams: From the experience we have had in New York during the past few months in competing with the operation of gas engines, I am inclined to think that at the usual prices prevailing for power service through the country—in additional costs, to say nothing of the many additional features of convenience, efficiency and safety—there is no chance for the competition of the gas engine with the electric motor. A short time ago, one of our customers, thinking he could make electric light for very much less with a gas engine, installed a plant, the latest in type and design, only to find that the gas he would consume under the guarantee of the manufacturers would cost annually, at $1.00 per thousand cubic feet, $3,500, whereas the aggregate of the bills of the preceding year for electric current was only $2,700. Here was a saving of about $800, and the plant has never run an hour and can be purchased, I think, at a low price. In the last four or five months the agents of the New York Edison company have taken out an average of fully six gas-engine plants; to such an extent has this process been going on that I think there are few gas-engine generating plants left in the city. This has been done without any concessions from the usual prices.

Mr. Lieb: I think the experience of every company in the United States operating motors to any considerable extent is entirely at variance with Mr. Cooper's contention that the gas engine is at present a formidable competitor of the electric motor. I am sure it is not in any of the larger cities, and that without making rates as low as the minimum that Mr. Cooper has in mind for the electric motor.

Mr. F. W. Bowen (Kenosha, Wis.): For the information of some of our members who may not be thoroughly conversant with the cost of the two classes of power, I would say that the lowest estimate for a gas engine is 20 feet of gas per hp-hour. Twenty feet of gas at $1.00 per 1,000 means two cents per hp-hour, which would mean that you would have to sell at two and two-thirds cents per kw-hour in order to compete with the gas engine if it were simply a question of the hp-hour. If you find that you can buy your gas at a less price—such as 80 cents, as is often the case—you must sell your wattage at two and one-eighth cents per kw-hour in order to compete with the horse-power cost of the gas engine. But to my mind it is not a question of the wattage per kilowatt or the power per hp-hour; it is a question of the efficiency of the electric motor as compared with the gas engine, not from the initial cost of the power that is involved, but from its applicability to the work. I know we have many cases where if the price of current per hp-hour were ten times the cost of gas per hp-hour, the current would still be used. So, to my mind, it is not a question whether or not we can compete with gas as a motive power, but a question of getting people to use electric motors for the uses where they are applicable in their business.

Professor Morgan Brooks (Urbana, Ill.): Power derived from a shaft is commonly sold by contract, whereas electric current is more often sold by meter, requiring payment only for the power actually used. One horse-power may cost 25 cents per day by contract and only 15 cents by meter, in spite of the higher rate for the metered power if used continuously. Thus the method of charging has to be considered as well as the apparent rate.

Mr. Arthur Williams: I do not think the impression should be given in this meeting that a gas engine can be run with an efficiency of 20 feet of gas consumed per horse-power; I know of no test where they have consumed less than 30 or 40 feet of gas per horse-power.

Mr. Bowen: I was speaking of the ordinary hit-or-miss gas engine; in that class 18 feet of gas per hp-hour is easily obtained.

Mr. C. W. Koiner (Oneida, N. Y.): I do not think that central stations have anything to fear from competition of gas engines with electric power in the average town. For instance, in Oneida, where we control both the gas and electric power, we are selling our gas for power purposes at the rate of $1.00 per 1,000 as against electric current for power purposes at from two to ten cents per kw-hour. The customer must use a very large quantity of power in one month in order to have the advantage of the two-cent rate. We cut the price on gas to $1.00 per 1,000 feet in order to keep out the gasolene engines. Gas engines, as a rule, are not quite so reliable as the motors, and sometimes a place may be stopped for a considerable time owing to their failure. In every case where we replace a gasolene motor the customer is perfectly satisfied and would not change because of a slight increase of cost. The cost does not as a rule run so high as they anticipated it would, for the reason that they always figure on the maximum power. They do not take into consideration that the motor is run the greater part of the time at one-tenth of the power it is capable of developing. We have to bring these points to their attention. I do not think that any gas company can afford to sell gas for less than $1.00 per 1,000 in the average town, because with the plant in good shape gas can not be put in the holder and distributed for gas-engine purposes for less than $1.00.

Mr. Hartman: In regard to the matter of gas-engine service as against electric-motor service, it seems to me there is an element entirely apart from the efficiency of the gas engine that appeals to the customer. At Canton, O., we have competition with natural gas at 25 cents per 1,000 feet. We all know that natural gas is more efficient for use in gas engines than is manufactured gas. Notwithstanding that, we have over 800 horse-power of electric motors connected in this town of 30,000 inhabitants, and have no difficulty in adding to that service. Our customers find that reliability of service is more important to them than the cost. Another point — it was mentioned by one of the previous speakers—the efficiency of gas engines as given in circulars and by the gas-engine agents is based on the rated load of the engine. As a matter of fact, hardly any one runs his engine at its proper normal load. The engine runs normally at considerably less than its best efficiency, and the consequence is that the amount of gas required is largely in excess of the figures quoted.

Mr. Frederick Pearson (Chicago, Ill.): If in order, Mr. President, I should like to make a few remarks on this subject. Returning to the original subject of Mr. Cooper's paper, and referring especially to the multi-voltage system of speed control—experience has proven, I think, that for the equipment of machine tools and similar machinery in manufacturing establishments, the two-step or 110-220-volt system with variable field for the intermediate speeds has proven entirely satisfactory when operated on the three-wire system. The multi-voltage method of control is not so well adapted to machines operating under a nearly constant load, as, for instance, air compressors, ammonia compressors, positive blowers, and large motors driving machine tools in groups. In such cases it would be far more advisable to use a larger motor frame and obtain speeds above and below normal by means of a wide range of field variations.

With regard to the statement that there is a large economy in individually driven machine tools, I wish to say that this statement should be qualified. It will not always prove practicable to equip a large number of small tools with individual drive. Under average conditions it will prove far more advisable to arrange to drive small machine tools in groups of eight to twelve tools driven from one large motor coupled with countershafting. Of course, where the tool is large enough to require, say, from two to five horse-power it would prove profitable to use individual drive.

As to the gas-engine proposition, I have in mind two or three gas engines recently displaced by motors, in which the gas consumption ran as high as 35 or 40 cubic feet per hp-hour, which placed on an electrical equivalent would mean seven to ten cents per kw-hour. This, however, was not the principal reason for making the change in motors ; it was done principally on account of the better adaptability of motors to the work ; the better speed regulation, less attention required, as well as smaller cost of maintenance. I know of several cases where motors operating on a sliding-scale rate of from ten to five cents per kw-hour have displaced gas engines permanently.

MR. ARTHUR WILLIAMS : A moment ago I gave some figures of average consumption per hp-hour for gas engines. I want to correct that statement to this extent—that these figures obtain in actual practice. A gas engine of 10 horse-power will hardly exceed an average load of three or four horse-power, at which point it is very inefficient. I recall figures showing 60 cubic feet of gas consumed per hp-hour.

Mr. F. Ellwood Smith: I have had some little experience with gas engines as against motors. I have two instances in mind. We had a gas engine in use in a small printing establishment several years ago, and the owner was anxious to put in an electric motor on trial. It was put in, and several months after that he told me he considered it would be cheaper for him to pay $12 a month for current for the motor than to pay what it had cost him for the gas-engine service. As a matter of fact, his bills did not run over $7.00 or $8.00 per month. I had another case recently. A man put in a gas engine of 15 or 20 horse-power. At the time it was put in I tried hard to put in a motor, but the gas man got ahead of me. A short time ago the man telephoned and asked if he could get a motor temporarily. I went to see him and found that his gas engine had broken down. I happened to have idle a 10-hp induction motor, and I had it in his place that afternoon and the current turned on. He did not want to buy the motor, but agreed to pay $10 monthly rental for it in addition to the cost of current. He has been using the motor six months. The bill for the rent of motor and current for the first six months was over $70. He made some objection to the high charge, as he said, but we did not make any special price to him. The price was about 6.3 cents per kw-hour; his gas cost him $500 a year, and the motor current at the rate named would cost him $800 per year. He has paid every bill since. The smaller price of the gas did not throw out the motor.

Mr. Almert: At a recent meeting of the steam men in this city, a conservative gas-engine representative stated that they had left off representing that gas engines needed no attention, and even with their small units they will not guarantee uninterrupted service unless an attendant of superior intelligence to that of an ordinary steam engineer is put in charge of the plant.

The President: We shall be pleased to have Mr. Cooper close the discussion on this paper.

Mr. Cooper: The discussion of this paper seems to have taken a turn irrelevant to the subject in hand. I did not intend that the discussion should rest on the remark I made at the close of my paper. I only threw out as a suggestion from my experience that the small manufacturing plants were using the gas engine to some extent. They are certainly crowding into small quarters where they can connect up with a steam engine, and my idea was that some business might be worked up in that line.

As to operating variable-speed motors on the three-wire system, so far as my experience has gone it has been difficult to get permission to operate motors on the three-wire system. In Cincinnati they will not allow anything larger than a one-hp motor on their circuits. Of course, any variable-speed motor would have to be smaller to work on the circuit. If it is true that the Edison central station will allow motors of any size on their three-wire circuits, it opens up a new field, which the electrical companies will do well to follow up.

THE PRESIDENT: The next matter to receive our attention this afternoon is the report of Mr. Robert L. Elliott, of Chicago, on Theft of Current.

Mr. Elliott presented the paper, which will be printed only in pamphlet form for the use of active members.

THE PRESIDENT: The next report is that of Mr. L. C. Van Ness, of Lincoln, Neb., on Lost and Unaccounted-for Current.

LOST AND UNACCOUNTED-FOR CURRENT

When this subject was assigned to me I hoped to be able to present a tabulation of records showing lost and unaccounted-for current from a number of stations, but I was disappointed in getting some of these records. Instead of a tabulation of results I will only attempt to discuss the subject in detail, and try and show how the different elements may be calculated and to what use this information may be put once it is determined.

This may not be as interesting to central-station men who now know what their lost and unaccounted-for current is, but it will be of more value to those who do not know, if they will attempt to apply the methods to their own conditions.

Lost and unaccounted-for current in high-tension transmission lines will not be discussed here, as an inductive drop plays an important part, and a study of conditions of existing lines would probably reveal embarrassing errors in original design which were practically unavoidable at the time the design was made.

The study of lost and unaccounted-for current in distributing systems is not only interesting work, but it almost invariably brings to attention conditions that can easily be remedied and the efficiency improved thereby.

Lost and unaccounted-for current in alternating distributing systems may be classified under four heads:

Transformer iron loss

Resistance loss
Meter shunt loss
Unaccounted-for current

For direct-current distributing systems, lost and unaccounted-for current may be classified under three heads:

Resistance loss
Meter shunt loss
Unaccounted-for current

These headings will be described briefly, and I shall endeavor to show that the losses may be accounted for, and that this accounting will, in itself, suggest means to reduce the loss.

Transformer-core loss is very easily calculated by multiplying the loss per transformer times the transformers in circuit, times the hours of operation, when the transformers are all of the same size. When various sizes are used it may be calculated for the different sizes and footed for the total. If transformers have not been tested in the testing-room, the makers' guaranteed loss may be used if due allowance is made for aging of the cores. An allowance should also be made for the voltage under which the transformers are operated, if makers' tests are not at the same voltage at which transformers are operated. Within small limits core loss will increase about two per cent for each one-per-cent increase in voltage over tested voltage. A comparison of two districts, one supplied by isolated transformers and the other by individual transformers, will at once give us an idea of how much money might be spent to install a three-wire secondary system, as much less transformer capacity will take care of the same load in three-wire network than with isolated transformers. In case of very large installation near the shop, it may be advisable to make arrangements to cut out certain transformers during period of light load. In case there is practically no morning peak, a portion of the transformers may be cut out at 10 or 11 p. m. and left out until dusk of the following evening.

A comparison of the cost of generating this particular amount of current for that time with the cost of labor incurred in cutting out and cutting in transformers, would determine whether or not this would be a profitable arrangement. Remote control switches have been proposed for doing this work, but as it is necessary to cut out both primary and secondary of a transformer on a three-wire system, the switching apparatus becomes complicated, and it is doubtful if this may be done profitably.

Resistance losses may be calculated in several ways. The simplest, and probably the most satisfactory way, is to compare the average voltage of the lamps on a circuit with the voltage carried at the station as determined by station records. This will show a certain variable difference in voltage due to the load on the station at any particular hour. This difference in voltage represents the C R and reactive drop of the feeders, which, multiplied by current carried by feeders at the same time and the power factor of the circuit, will give us watt loss in our distributing system for that particular load. This may be calculated for as many different loads as is thought advisable and the summation taken for an average day of the period. The information necessary for all this calculation is available in almost every station, as indicating ampere-meter readings are usually taken at intervals of one-half hour or hour, and every central-station man will claim that his lamps are run at very nearly their rated voltage.

There is another and more complicated way of calculating resistance losses, which may be used to check the method described previously. The loss in the feeders may be calculated by taking size and length of feeders and calculating the C2R loss for one ampere flowing to the first point of division. From this point to the end of the circuit, if the one ampere is considered as dividing in proportion to the connected load on different branches, the C2R loss may be calculated accurately to the end of the feeders. From this value per ampere the all-day losses may be calculated by taking the station ampere-meter readings at intervals during the day and squaring them and multiplying by the loss per ampere. By taking the station output for the same period, a certain relation may be established between the C2R loss and the output of the station. This ratio may be applied to the output of the station for the period, to determine resistance losses for the period. It must be borne in mind that the losses increase or decrease in proportion to the square of the output.

Secondary losses may be calculated in the same manner, and transformer resistance losses may be calculated by using the rated loss at the load carried by the transformer at different periods of the day. This process is somewhat tedious, and I think the first method will give the resistance losses fully as closely as the second method, and it has the advantage of being rapid and requiring very little data.

The cost of furnishing this current that is lost in the feeders will furnish an indication of the time when it will be proper to make an expenditure to reinforce the lines. If all feeders are carried on one 'bus-bar and feed independent districts, it may be necessary to consider also a feeder regulator to overcome excessive drop due to increase of business in one district. The figures to compare are, then, interest and depreciation on reinforcements, cost of resistance losses, and cost of regulator losses.

Meter shunt loss is calculated by determining by test the losses of each type of meter and each size and multiplying the result by the number of each type and size.

Meter shunt loss, while not considered serious, will sometimes show more than transformer iron loss. This is quite possible in a residence district fed by a carefully designed secondary network. Many small consumers may be served by small transformer capacity, but they require a meter per consumer, and unless losses are small per meter, the total loss is a serious item. The only means of reducing this loss is by installing meters with less loss per meter, or by using ampere-hour meters. It has occurred to the writer that if meter manufacturers would devote as much time to developing an ampere-hour meter as they spend trying to improve the wattmeter, they might produce a meter that would serve our purpose much better. We all claim that we give good regulation, and if this is true we can calculate the consumption for alternating incandescent load as accurately with a correct and sensitive ampere-hour meter as it can be measured by a wattmeter. We should then eliminate a loss that amounts to from 16 to 36 kw-hours per year per consumer.

The unaccounted-for current is all that we are unable to trace accurately. This includes faulty registration of meter, elimination of meters from the records, theft of current, and leakage by grounds in underground systems. There is really no good excuse for losing records. However, it sometimes happens, and the only way to check this is to go over the districts covered, counting connections and comparing with the number of consumers shown by the ledger.

The resistance losses for the direct-current system should, I think, be calculated by the first method given for alternating system. If we attempt to calculate it by the second method the problem is almost endless, on account of interconnecting feeders and mains. The only error that can appear in calculation by the first method is error in assuming the voltage at which the lamps are operated. This should be checked by numerous tests at all hours and over the entire system. It is not sufficient to assume that lamps are run at rated voltage because the management claims that they are giving an average regulation within a certain per cent. It is possible that a test for this purpose will develop some deficiencies in regulation that are not suspected.

The following are some figures on three representative circuits:

TABLE I

TABLE SHOWING DATA ON THREE FEEDERS AND LOSSES ON SAME

	1	2	3
Voltage	2,000	1,000	2,000
Connected Load, Kilowatts	337	461	351
Maximum Demand, Kilowatts	176	81	88
Number of Transformers	12	15	145
Cap Transformers, Kilowatts	130	135	160
Number of Meters	182	266	308
Trans. Iron Loss, Per Cent	3.6	15.4	42.7
Resistance Loss, Per Cent	4.5	6.5	6.3
Meter Shunt Loss, Per Cent	.8	5.2	1.4
Unaccounted for, Per Cent	13.3	1.7	1.1
Sales, Per Cent	77.8	71.2	48.5
Output, Per Cent	100	100	100
Output, Kw-hours	35.386	9,135	20,100

The first is a well-designed feeder supplying a business district on three-wire network.

The second is a carefully designed feeder supplying a residence district on three-wire network.

The third is a feeder with isolated transformers, such as we often find, that has been added to from time to time and no attention paid to economy of operation. This feeder supplies a mixed residence and business section, and could be, and was, made with very little expenditure an efficient distributing system. The data are not at hand to show just what efficiency was obtained after changing, but it would probably fall between feeders 1 and 2.

It may be noted that between feeders 1 and 2 the transformer iron loss is 3.6 per cent for No. 1 and 15.4 for No. 2. The actual watts lost in No. 2 are more than the watts lost in No. 1, but the lesser sales, due to its being a poorer district, raise its percentage of iron loss.

The meter shunt loss shows less, both in percentage and watts, for feeder No. 1 than for No. 2, for the reason that the consumers are fewer in number and the consumption greater.

The unaccounted-for current shows an abnormal amount under feeder No. 1, which indicates that there is some theft of current in that section. The natural course to pursue would be to check up all meters in that district, and, if no large meters were found dead, then it would be necessary to begin a search for taps taking current without measurement.

Feeder No. 3, while it appears to a great disadvantage beside Nos. 1 and 2, is by no means unusual. There are many operating under the same conditions to-day, and few realize the cost of this operation. For instance, the iron loss in this feeder amounts to 8,600 kw-hours per month. This, at the generating cost of one cent per kw-hour, amounts to $86 per month or $1,032 per year. The excess of this over normal transformer loss would pay interest on considerable investment for new transformers and secondary copper, and we should also be able to give better regulation.

TABLE II

TABLE SHOWING LEGITIMATE LOSSES ON FIVE CAREFULLY DESIGNED FEEDERS SUPPLYING ALL CLASSES OF BUSINESS

	Voltage	Trans. Iron Loss		Resistance Loss		Meter Shunt Loss		Output
		Watt-hrs.	Per Cent	Watt-hrs.	Per Cent	Watt-hrs.	Per Cent	Watt-hrs.
1.	1,000	28,488	6.76	23,923	5.68	14,916	3.54	421,000
2.	1,000	19,752	3.78	25,086	1.98	19,092	3.65	522,400
3.	1,000	28,680	9.56	17,026	5.00	23,316	7.77	300,000
4. . . .	2,000	20,712	5.01	29,691	7.28	24,504	5.93	413,000
5. . . .	2,000	42,576	8.55	28,867	5.79	18,720	3.76	477.600

Table No. 2 shows output and losses for an average winter day for five feeders, which have received considerable attention in the way of design. There is but one peculiarity in these figures, and that is that in feeder No. 4 the meter shunt loss amounts to more than the transformer loss. This is due to the fact that the feeder supplies a residence section by a carefully designed three-wire network. The conditions here were such that the transformer capacity could be so installed that very little more than the demand of the feeder was necessary in order to give proper regulation. On account of the large number of consumers, it was impossible to keep the meter-shunt loss down without using ampere-hour meters.

TABLE III

TABLE SHOWING LOST AND UNACCOUNTED-FOR CURRENT FOR A STATION FOR THE FIRST THREE MONTHS OF ANALYSIS

	TRANS. FE. LOSS		RESISTANCE LOSS		SHUNT LOSS		UNACCOUNTED FOR	
	Kw-hours	Per Cent	Kw-hours	Per Cent	Kw-hours	Per Cent	Kw-hours	Per Cent
January..	29,296	14.3	7,849	3.76	7,486	3.58	43,205	20.6
February.	26,163	14.5	6,588	3.66	6,625	3.68	36,096	20.1
March....	28,153	16.9	4,377	2.62	7,121	4.28	23,958	14.4

Table No. 3 will give an idea of some of the things that we may learn by an analysis of lost and unaccounted-for current for an ordinary station. This shows analysis for the first three months. It will be noted that transformer iron loss remains practically the same. The party making this analysis states that it will be cut something like 10,000 kw-hours per month in a very short time. This is not entirely due to the analysis of the lost and unaccounted-for current, as the requirements of the service demand an improvement in this line.

The resistance loss has been decreased by very little expenditure, simply because they found where the resistance loss took place.

They do not expect to reduce the meter shunt loss, but the unaccounted-for current has been reduced about forty-five per cent in three months. This was accomplished by looking up lost records, defective meters, and thefts of current.

The party making this analysis, in reporting says: "The work necessary to make this analysis easily pays for itself many times over, as it is very probable that we should not have discovered the theft of current or loss of records had it not been brought to our attention in this forcible manner."

These figures are not cited as representing average conditions. However, there are many sections to-day with alternating distributing systems in no better condition than this one was in January. While an analysis is not always necessary to get a station in good condition, I maintain that the information brought out in analysis of this kind will assist us greatly in tracing out inefficiencies that can easily be remedied.

L. G. VAN NESS, Committee.

THE PRESIDENT: The next order of business is the Question Box, edited by Mr. H. T. Hartman. I want to say for Mr. Hartman that he has been working hard to get the Question Box in the shape in which it is presented to you to-day, and I feel that this association owes him a sincere vote of thanks.

Mr. Hartman read the introductory to the Question Box, which will be found in Appendix D.

(Mr. Hartman, acting as secretary, in the chair.)

CHAIRMAN HARTMAN: The next business before the association is the report of the committee on the president's address.

Mr. Brady presented the report, as follows:

REPORT OF COMMITTEE ON PRESIDENT'S ADDRESS

National Electric Light Association:

GENTLEMEN: The committee to which the excellent introductory address of your president was referred for report on the suggestions contained therein, begs to make the following recommendations:

First—That a committee of three engineers be appointed by the president to report at the next annual meeting on the development of the steam turbine, and this committee further recommends that said committee be authorized to expend a sum not to exceed $1,000 in the investigation of the subject.

Second—We further recommend that a committee of three members be appointed by the president in accordance with the following recommendation contained in the president's address: "I would recommend to you, therefore, the appointment of a small committee of forceful men to watch the movements of other kindred bodies and engineering societies, to confer with them from time to time and to promote a closer relationship with them, so that their action may not be antagonistic to the members of this association."

Third—That a committee of three from various portions of the country be appointed to collect information and report to the association at its next meeting.

The committee further wishes to urge the continuance of a progress editor, and other reports on special subjects; also the continuance of the Question Box in its present form, which seems to fill all requirements and to result in a saving of time as against the former method.

In conclusion, the opinion of the committee to which was referred the president's address is that the address is of such general interest that it should be printed in pamphlet form and distributed to the members of the association. This, therefore, your committee would recommend.

Respectfully submitted,

Committee, { HENRY L. DOHERTY,
CHARLES L. EDGAR,
H. H. FAIRBANKS.

(On motion, the report of the committee was adopted and the special recommendations of the reports were authorized.)

PRESIDENT FERGUSON: Having finished everything planned for the public programme, we will resolve ourselves into an executive session.

(The meeting then adjourned to executive session.)

EXECUTIVE SESSION

President Ferguson called the session to order at 4.30 o'clock. Mr. Bean, of St. Joseph, moved that the words "and of associate members twenty dollars" be inserted in Article VII of the Constitution; this matter having been omitted from the amendment to the Constitution adopted at Cincinnati. The amendment was agreed to.

The report of the secretary and treasurer was read, as follows:

FINANCIAL REPORT FOR YEAR ENDING JANUARY 1, 1903.

RECEIPTS

Active members' dues, 1902	$6,185 00	
Active members' dues, 1903	1,040 00	
Associate members' dues, 1902	1,280 00	
Sales Reports, Twenty-fifth Convention	200 00	
Sales badges	130 00	
Sales advertisements in Proceedings	890 00	
Sales publications	76 00	
Receipts account arc-lamp fund	972 05	
Total receipts during year		$10,773 05
Balance from 1901		6,338 47
		$17,111 52

DISBURSEMENTS

Salary of secretary and treasurer	$999 96	
Salary of assistant secretary and treasurer	1,500 00	
Office rent	420 00	
Stenography and typewriting	269 15	
Report, Twenty-fifth Convention	275 00	
Printing and stationery, including Proceedings and papers read at Convention	2,600 21	
Postage, telegrams and telephone	805 26	
Traveling expenses	196 10	
Minor expenses, office	85 39	
Badges, Twenty-fifth Convention	144 30	
Testimonials	115 00	
Municipal fund account	76 10	
Arc-lamp fund account	855 00	
Excess dues returned	70 00	
Petty cash dr. to George F. Porter, paid	10 83	
Office furniture	17 25	
Total disbursements		$8,439 55

Balance in bank January 1, 1903	$8,521 74	
Balance in petty cash January 1, 1903	150 23	
Total cash on hand		$8,671 97
Balance on hand January 1, 1902	$6,338 47	
Apparent gain in balance on hand during year	$2,333 50	
Deduct dues paid for 1903	1,040 00	
Net gain in balance on hand for year		$1,293 50

ASSETS

Cash as per statement	$8,671 97
*Office furniture	266 00
Total	$8,937 97

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* Expenditures for 1902 not added, as they are offset by depreciation.

LIABILITIES

None

ARC-LAMP FUND

Balance on hand January 1, 1902	$33 50	
Received during year	972 05	
Total	$985 55	
Disbursed to committee	855 00	
Balance on hand January 1, 1903		$130 55

MUNICIPAL FUND

Balance on hand January 1, 1902		$2,848 30
Receipts during year, none.		

DISBURSEMENTS

100 copies Francisco's book	$25 00	
Expenses J. B. Cahoon, attending Convention American League of Municipalities	51 10	
Total		$76 10
Balance on hand January 1, 1903		$2,772 20

(On motion of Mr. Insull the report was placed on file.)

The committee on nominations then presented the following recommendations for officers for the ensuing year:

President, Charles L. Edgar, Boston.

First Vice-President, S. B. Livermore, Winona, Minn.

Second Vice-President, John W. Lieb, Jr., New York.

Executive Committee: Louis A. Ferguson, Chicago; Harry Bottomley, Fall River, and Alexander Dow, Detroit.

(Mr. Hewitt moved that the report be accepted and the secretary authorized to cast a vote of the association for the gentlemen named. The motion was carried.)

THE PRESIDENT: Professor Thomson communicated a paper to this convention, which was not read, on "The Development of the Electric Power Plant." As he was not here, I did not care to have the paper read, because it was a paper that probably he would not care to have presented by any one else. It is read by title.*

Professor Clifford requests permission to read by title a paper entitled, "A New Form of Arc-Light Photometer," by R. R. Lawrence, for later publication.†

The installation of the new officers being in order, I will ask Mr. Bean and Mr. Williams to escort the newly-elected president to the chair.

(To President-Elect Edgar.) I congratulate you, Mr. Edgar, and congratulate the association upon its wise selection of a president.

PRESIDENT-ELECT EDGAR: Gentlemen of the National Electric Light Association: I thank you for this honor. I recognize that it is an honor to be made president of this association. It was my good fortune to be vice-president in 1890. It is impossible to describe the difference between the meeting of the association in 1890, at Cape May, and 1903 in Chicago. I recognize that I have a hard row to hoe. Each president naturally desires to make his meeting somewhat better than the previous one; and I know you will all admit that I shall probably not make the meeting next year anywhere equal in interest and importance to that through which we have just passed. I do not know that I can say a word more to emphasize it than that the success of this meeting is due to Mr. Ferguson. We all feel it, and we hope he appreciates the fact that we know he has, as president, done more to promote the interests of the National Electric Light Association than any previous president.

(On motion of Mr. Scovil a vote of thanks was passed to the retiring president, Mr. Ferguson.)

PRESIDENT FERGUSON: Gentlemen, I am much obliged to you for your vote of thanks, and I wish to return to you my sincere thanks for the kind attention you have given to the reading of papers presented at this convention, and also for the assistance you have all afforded me during my administration as president.

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*See Appendix B for text of paper.

†See Appendix C for text of paper.

PRESIDENT-ELECT EDGAR: We will now have the report of the committee on standard rules for electrical construction and operation. Mr. Ayer, Captain Brophy and myself are members of the committee. Mr. Ayer will make the report.

REPORT OF THE COMMITTEE ON STANDARD RULES FOR ELECTRICAL CONSTRUCTION AND OPERATION

National Electric Light Association :

GENTLEMEN : The National Code of Rules, as you understand, is promulgated with the approval of a number of engineering societies. About a year ago the underwriters formulated a set of rules covering the method of constructing high-tension, constant-potential lines. The object of these rules was to establish, in advance of the development of the industry to any great extent, the proper methods for running transmission wires rather than distribution wires. The rules as the underwriters offered them were submitted to the committee of the American Institute of Electrical Engineers, who discussed them, reaching a result, and they were referred to the annual meeting of the National Board of Fire Underwriters' inspectors for formal adoption without referring the matter to the code conference. This association, through its president, requested a postponement of one year in regard to the adoption of rules of such importance, and the action of the institute in recommending the rules was withdrawn. The underwriters allowed the matter to go over for a short time, and appointed a meeting in Boston in January last, when the representatives of this association could be heard. At that meeting, the committee with your president and members of the executive committee called the attention of the underwriters to the fact that the rules were of such unusual importance that they should not be considered as minor changes, but should be referred to the conference committee, composed of representatives of the various national organizations. This was agreed to, but at the same time occasion was taken at the meeting in Boston to discuss these rules and modify them somewhat. The rules were printed in their modified shape and copies sent to the members of the various institutions, and another meeting was held in March. Your president and some members of the executive committee were present at that meeting. We gained a good many points, and I believe the rules that the underwriters finally agreed to, with one exception, all make for good construction.

There is one rule to which your committee objected seriously, which, in discussing it, we called the 90-foot rule, because it says if you approach nearer than 25 feet to any building in running a line along a street the wires must go above the cornice of the building so as not to be a menace to firemen in the event of fire. There are conditions where, under such a rule, you might have to put up 90-foot poles. The underwriters gave up pretty nearly everything they started out to get, except the 90-foot rule. It is thought that they should not make any outdoor rules. Of course, they have a right to make any rules they please, but a violation of them is not a misdemeanor, and the only penalties they can attach is to increase the insurance rates.

It is proper to state that in the beginning of the discussion with the underwriters it was clearly stated by Mr. Ferguson that we, as representatives of the National Electric Light Association, had only the authority to confer with them, to express our ideas as to what was proper, to assist in getting the best possible results, and to bring the matter before the association after our work was done, but we could not obligate the association in any manner.

The report of this committee would have been formulated in proper shape and distributed to the members before the meeting, but owing to the delay in determining the rules we were unable to secure a completed copy of them until last Friday. The first advance copies we had were handed to members of the committee on Thursday and Friday of last week. (Mr. Ayer then read the 90-foot rule.)

The other changes in the rules relate principally to the action of the underwriters with regard to the grounding of secondaries or neutral wires in the event of the use of the three-wire system. Heretofore they have refused to take any action. They do not now object, but they permit it to be done, leaving it optional with the companies as to whether or not they will ground the neutral. At first the underwriters were opposed to it, then passive without action, permitting it by inference, and now they officially permit it to be done.

Another of the rules relates to signaling systems; to the governing of wires for telephone, telegraph, district messenger call, police circuits, fire and burglar alarms, and similar systems, in that they must not be put into the same conduits or manholes with the electric-light wire, nor run on the same poles, with certain exceptions. (Mr. Ayer then read the rule in question.)

The work has been rather arduous in connection with the rules this year. We have done something in the way of modifying the rules. The code conference consists of nine national organizations, three of which are insurance bodies; they are in the minority. Prior to the establishment of a code conference the underwriters made rules, and other people made rules, but the only rules that annoyed central-station men were the underwriters' rules. Through the work of the code conference we have been able to get a more satisfactory set of rules. We are in a position to do exactly what we did in regard to the high-tension wires; we were able to take rules that were prohibitive in many ways and put them into such shape that I am ready to say they stand for first-class construction and proper rules, with the exception of the 90-foot rule. We shall always be able to secure much more harmonious action, and action that will result to the benefit of all concerned, by continuing to co-operate with this conference committee on standard rules.

Respectfully submitted,

Committee, { WILLIAM BROPHY, Chairman,
JAMES I. AYER,
CHARLES L. EDGAR.

Mr. Scovil offered the following resolution :

"*Resolved*—1. That a vote of thanks be tendered the committee for its diplomatic and effective efforts to secure a reasonable and practical set of rules.

"2. That the association expresses its appreciation of the importance of co-operation with the National Board of Fire Underwriters in work where mutual interests are involved, and that it recognizes the value of the results obtained since there has been such co-operation.

"3. That a set of the rules and the report of the committee be printed and sent to each active member of this association, and that action on said committee report be deferred until the next regular meeting of the association.

"4. That any change in the personnel of the committee for the coming year be referred to the incoming president for such action as he may deem desirable."

(The resolution was unanimously adopted.)

Mr. Scovil then offered the following resolution :

"*Resolved*, That the proper officers of this association suggest to the National Underwriters' Association that they would consider it a compliment if the underwriters could see their way clear to include the cost of electrical inspection in the insurance rates."

(The resolution was adopted.)

PRESIDENT EDGAR : Under the constitution it is the province of the president to appoint a secretary and treasurer, subject to the approval of executive committee. I have in mind to make a somewhat radical change the coming year. In past years there has been an active secretary under salary, and an active assistant secretary under salary. I desire this year to appoint a gentleman as secretary and treasurer who will take it as an honorary position, leaving the work and the compensation to be given entirely to the assistant secretary, and, subject to the approval of the executive committee, I am intending to appoint Mr. Ernest H. Davis, of Williamsport, Pa., as honorary secretary and treasurer, to serve without salary. I am assured that he is willing to accept the position, but will accept it only on the terms that he is not to be paid for doing so.

MR. INSULL : In order that there may be no embarrassment and no reflection on the president who may follow Mr. Edgar, I wish to give notice that at the next regular meeting of the association I propose to change the by-laws, making the office of secretary-treasurer an elective office ; only the representative of an active member being eligible to the office. I give this notice because I have served on a number of nominating committees and it is a source of great embarrassment to distribute our honors around ; I think the office of secretary-treasurer should be an honorary position, and I think the election should come from the members of the association and the position be accepted by the gentleman elected.

MR. AYER : Mr. President, at the last annual meeting of the Association, I moved a resolution that we meet in St. Louis in 1904. Certain difficulties have arisen. The Exposition opens in May and it is likely to be in a chaotic state and not a proper time for our meeting. The further objection is raised that meeting at a place where there is an exposition would interfere with the continued good work of the association ; we could not concentrate our attention upon our business as we

National Electric Light Association, or by the Edison Association, but you would have all the foreign papers as well, so that the National Electric Light Association and the Association of Edison Illuminating Companies would be benefited through the papers turned over to them. This is entirely a different proposition from trying to get two conventions in one year.

MR. C. F. HEWITT: That does not eliminate the fact that you will virtually have two conventions and two expense accounts for the members to meet in attending them, and I am very much afraid there are a number of small companies that can not afford to send delegates to two meetings in a year. I represent a small company and do not think our directors would feel disposed to pay my expenses to two conventions.

MR. INSULL: I propose an amendment to Mr. Ayer's resolution; that we first vote on the first portion of his resolution, referring to the regular annual convention of the association next May. After that resolution is voted on, if it is passed, I will propose another resolution: that we recommend to the next convention of the association that it take part in a meeting with kindred organizations in St. Louis next September.

(Mr. Scovil seconded the motion.)

MR. W. WORTH BEAN (St. Joseph, Mich.): While we must not lose sight of the point of attending to our business properly in May or June, and of having a good convention at that time, we must not forget that we are under some obligation to go to St. Louis.

MR. AYER: Before you vote on the amendment, it is pertinent to say that if we do not take some definite action now, Professor Goldsborough can arrange no programme for us to carry out in joint meeting, for the reason that our action would be taken in May next, after their work was done and the machine was moving. This matter must be decided now, if at all. They have offered us a considerable honor in expressing their intention of delegating to us the care of the foreign papers relating to the industry in which we are engaged. If we refuse that honor, and decline it because it is impracticable for some men to come to two meetings, or some considerable element of the members to come to two meetings in one year, and they do not know which one they want to come to—if we are going to decline this dignity because of any such reasons, then we want to vote as suggested in the last motion, to defer the matter; but I would much prefer to decline the honor if that is our attitude.

MR. INSULL: My motion refers solely to the holding of the next annual convention in May. If that motion is carried I will make another motion, after the explanation given by Mr. Ayer, that the association accept an invitation to take part in a joint conference at the St. Louis Exposition next September.

(Mr. Insull's motion was carried.)

MR. INSULL: I make this motion: That this association accept the invitation of the representatives of the St. Louis Exposition to take part in a special conference of electrical organizations in St. Louis in September, 1904. In making this motion I wish to remind you that 1904 will be the twenty-fifth anniversary of the introduction of one branch of our business, namely, incandescent lighting. It has been broached during this meeting that an effort should be made to contribute to the St. Louis Exposition an historical exhibit of the art, showing the growth of the industry from its inception; and I think it is very proper that we should take part in any conference that may take place at that time.

(The motion was carried.)

PRESIDENT EDGAR: I think I should like to say, for the information of the members of the association, that, representing the electrical interests of Boston, I am proposing to ask the convention to meet in Boston next year. That is a matter which is to be settled by the executive committee.

A meeting of the executive committee, made up of the members present in the meeting-room, was held, and it was decided to have the next convention in Boston.

Mr. Bowen called the attention of the members to the great necessity which existed for the adoption of a uniform size for catalogues, reports, etc., issued by those engaged in the electrical industries, and stated that one of the large manufacturing companies had on file in its office 1,678 catalogues, and among these were 653 different sizes.

Mr. Ferguson moved that the question of standardizing catalogues, reports, etc., as to their size, be referred to the president for such action as he may deem desirable.

Mr. J. G. White moved that the thanks of the association be tendered to the electrical interests of Chicago, particularly the officials of the Chicago Edison Company, for the information, assistance and attention given and rendered by them to the delegates to the convention, and that the secretary send a copy of this resolution to the chairman of the entertainment committee.

(The motion was carried.)

The convention then adjourned.

APPENDIX A

Decorative *and* Sign Lighting

ILLUSTRATED

A Report made at the
Twenty-Sixth Annual Convention

of the

National Electric Light Association

held at

Chicago, Illinois
May 26, 27, 28, 1903

by

Arthur Williams

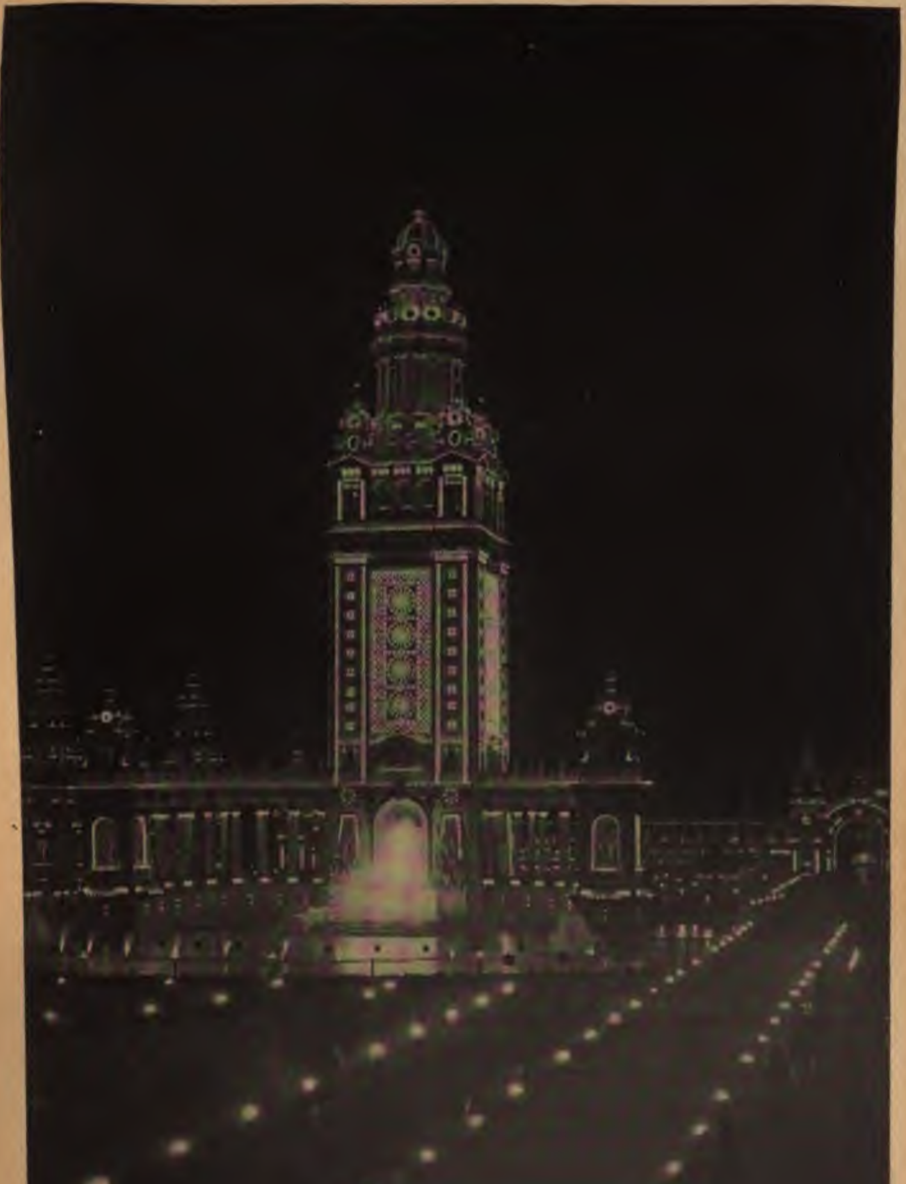
Printed—not Published

Press of
The New York Edison Company

1903

The Pan-American at night.

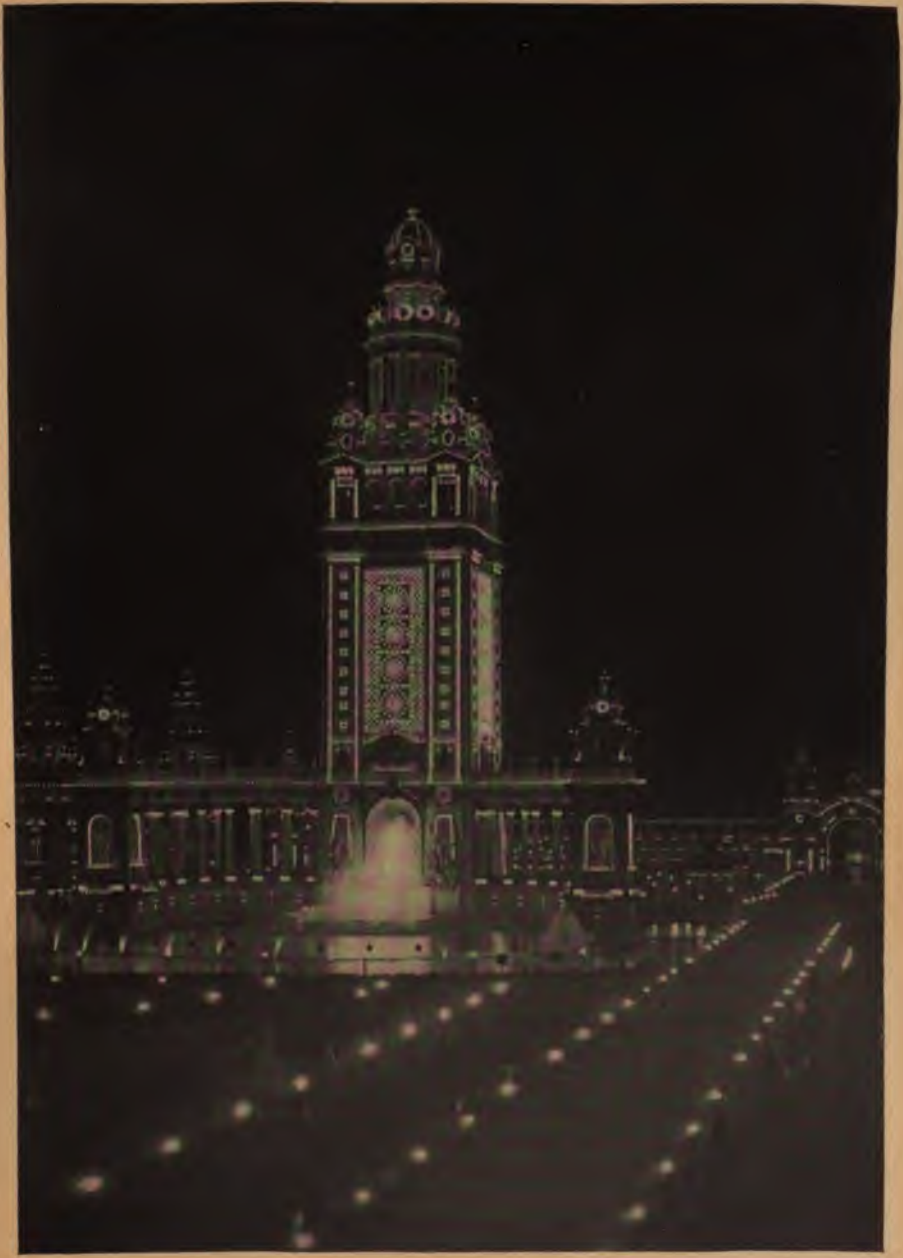
Courtesy of J. W. Lieb, Jr.



Stieringer's Tower of Light at the Pan-American, Buffalo, 1902.

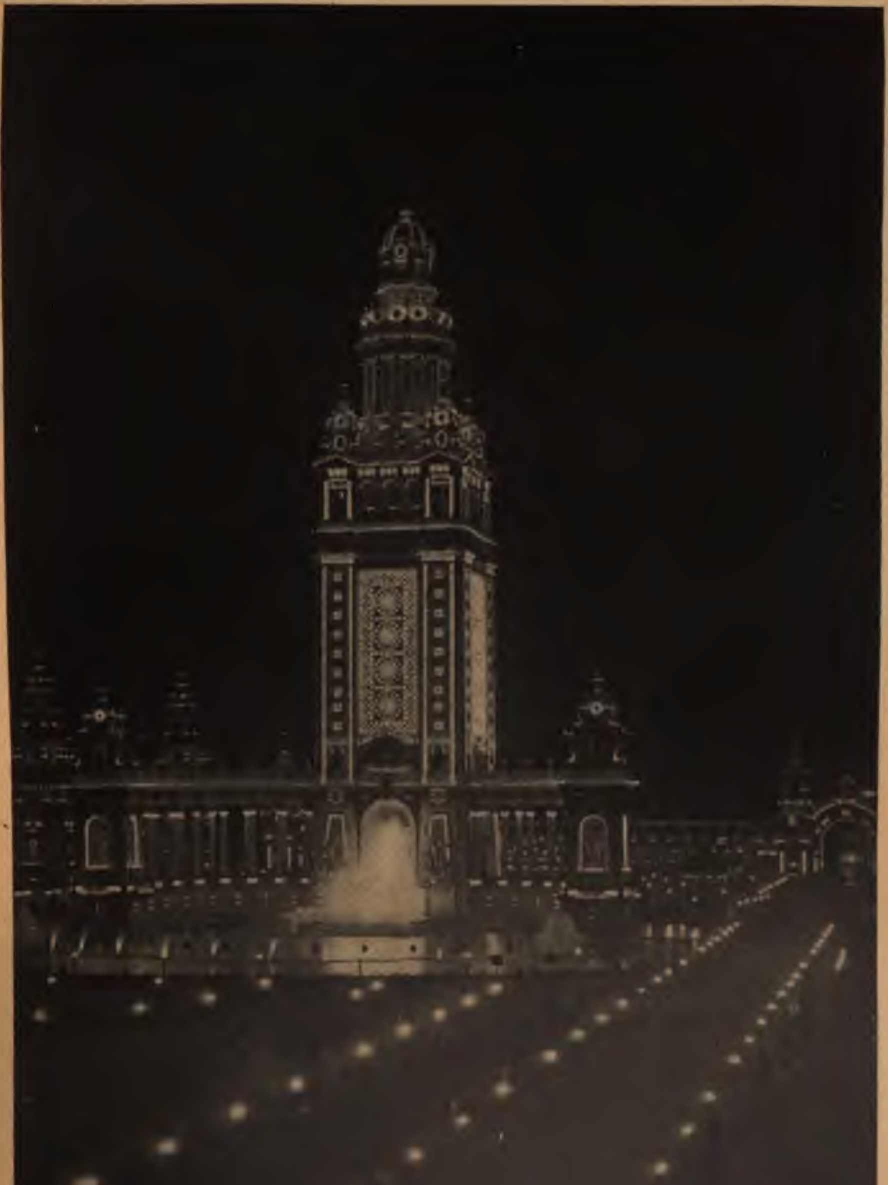
Courtesy of *The General Electric Company.*

The Pan-American at night. Courtesy of J. W. Lieb, Jr.



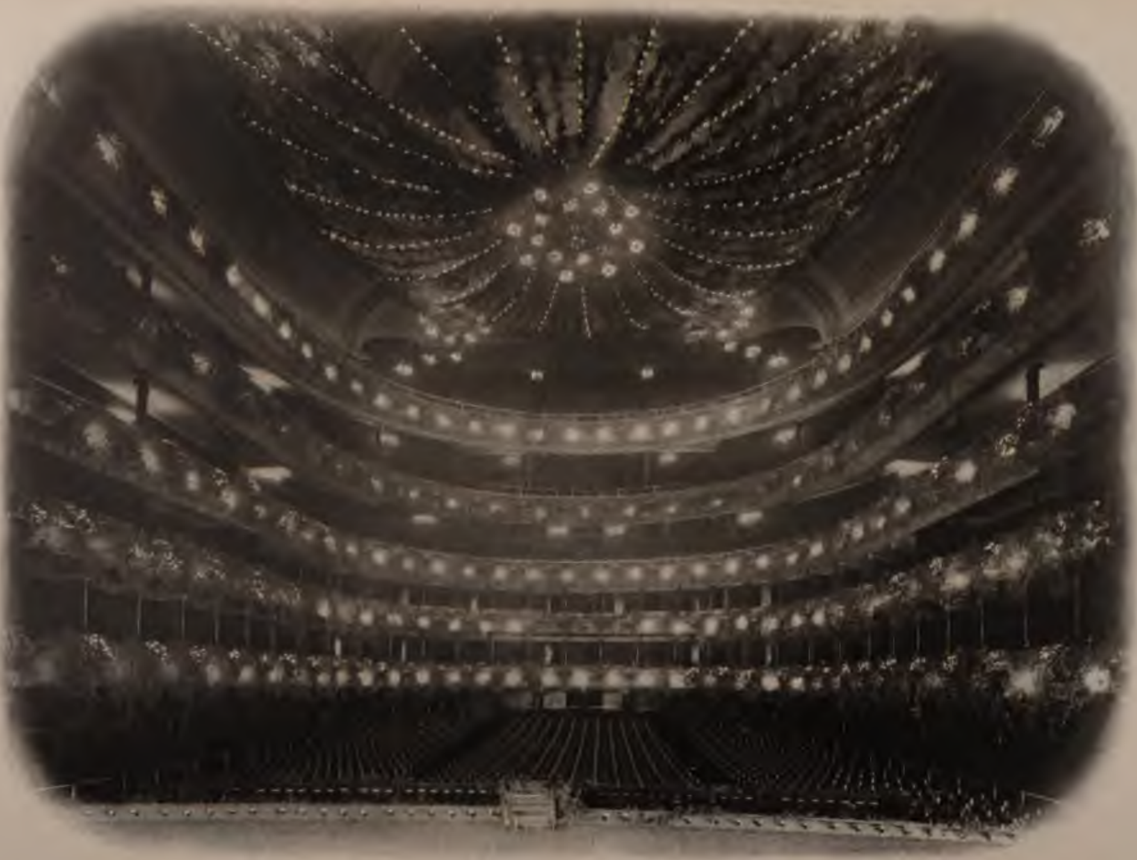
Stieringer's Tower of Light at the Pan-American, Buffalo, 1902.
Courtesy of *The General Electric Company.*

The Pan-American at night. Courtesy of J. W. Lieb, Jr.



Stieringer's Tower of Light at the Pan-American, Buffalo, 1902.

Courtesy of *The General Electric Company.*



Interior of the Metropolitan Opera House, New York City, as decorated for the visit of Prince Henry of Prussia. The entire decoration consists of electric lamps and smilax artistically strung and festooned. Courtesy of *The Eblight Company of America.*

Decorative and Sign Lighting

THE electric light, depending in no measure on a fixed position, unable to communicate fire,* and self-protected from the elements, offers unrivaled and heretofore unattainable advantages for the purposes suggested in the title of this article.

One method of utilizing these advantages permits the lamps to be concealed, and light to be obtained by reflection. Illustrations are found in the lighting of a room from behind the cornices; of a window or show case, (the latter constructed wholly of plate glass or having a glass front) with the lamps concealed behind metallic reflectors; of an art gallery in which the lamps are held and all but concealed in semi-circular reflectors, suspended from the ceiling, projecting light to the pictures on the wall; or here the lamps may be placed on the larger frames of the pictures themselves and the source of light entirely hidden.

The incandescent lamp permits the elimination of the conventional fixture creations of various orders and materials with which we have become familiar from infancy. Well designed fixtures have uses but not as often as is supposed. One suggestion is found in church or auditorium lighting in the substitution of an artistic, almost invisible, metal band carrying the requisite number of lamps, around the upper part of the supporting columns at or near the capitals, or following the lines of arches, windows or

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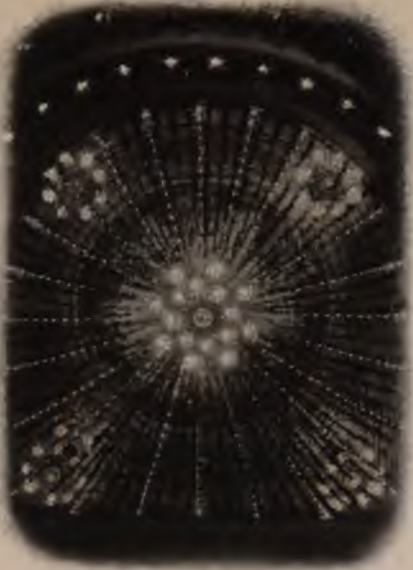
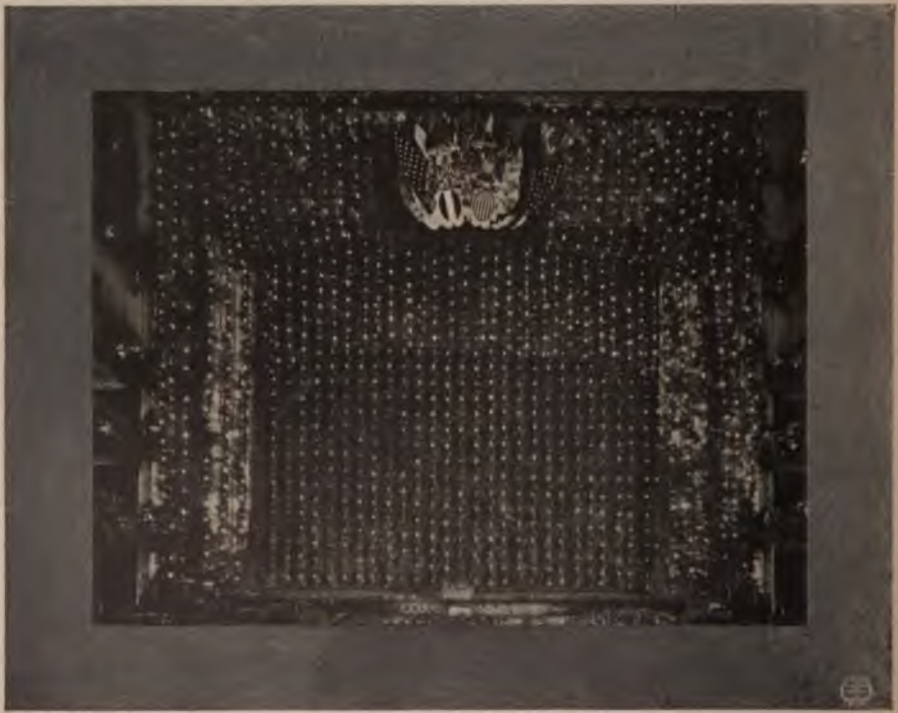
*Omitting conditions under which the small degree of heat radiated from the bulb is stored and becomes effective accumulatively.



Dome of the Metropolitan Opera House, from below, as decorated for the visit of Prince Henry



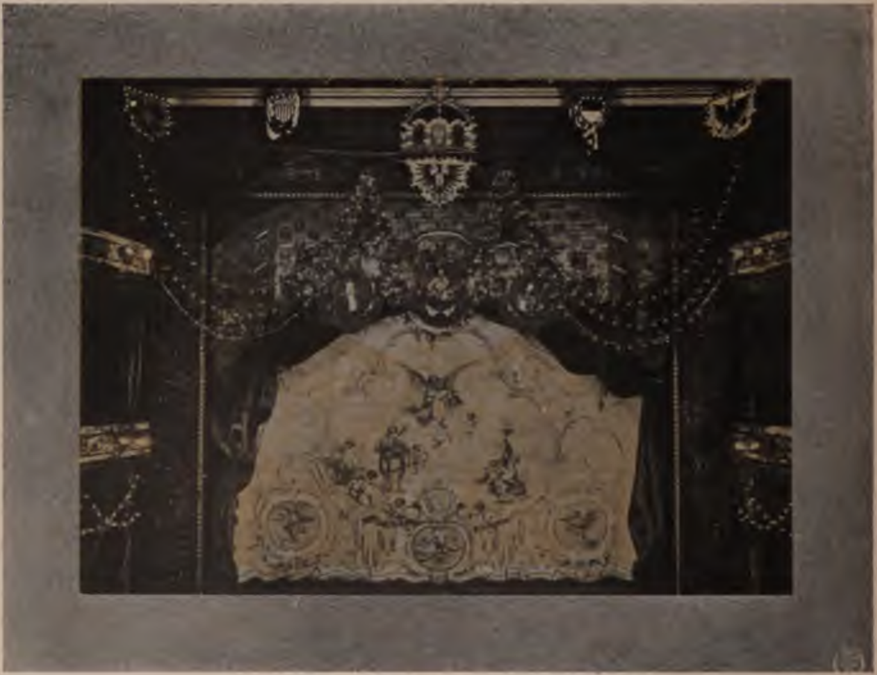
Curtain at the Metropolitan Opera House designed for the Special Performance given in honor of Prince Henry. This curtain, composed of smilax contained more than 3,000 incandescent lamps and was raised and lowered intact for each act of the Opera. The Eblight System was employed throughout the building on this occasion.

decorations. The removal of all fixtures oftentimes results in better acoustics, augments to the fullest extent the suggestion of size, and subordinates everything to the architectural design of the edifice.

These suggestions relate to necessary illumination made artistic—artistic because nothing is in evidence but the illumination. Decorative lighting is something else. Here the incandescent lamp has the best chance to show off because it alone of all possesses the quality of availability. No other lamp is possible for the illuminated fountain now used indoors as well as out; for the tiny lights amongst flowers and smilax on the table, in bridal decorations, or for some great festival or other occasion.

It has been the custom on fete days to mark the outlines of the public buildings of Paris with myriads of gas jets but their use is confined to good weather and even then the effect cannot be said to compare with that, in white or colors, produced frequently on our own public buildings, with incandescent lamps. Picture the wonderful scenic effects accomplished in the illumination of the Pan-American buildings, the thousands of incandescent lamps first appearing at twilight with the slight heat discoloration of the filament and gradually increasing until the brilliancy of their full candle-power was reached. And with that incomparable scene consider the tameness of the effects produced at the Glasgow and Berlin exhibitions of the same year where the use of electricity was confined to a few exhibits and to still fewer electric signs.

The electric light, in its application to signs, serves possibly a more utilitarian purpose, but not necessarily one that is entirely inartistic. Those who have stood on the river embankment at London and there seen across the Thames a simple sign of immense proportions spelling in colors a single word, may have thought the view, in its many repetitions, monotonous, yet, shining alone in the

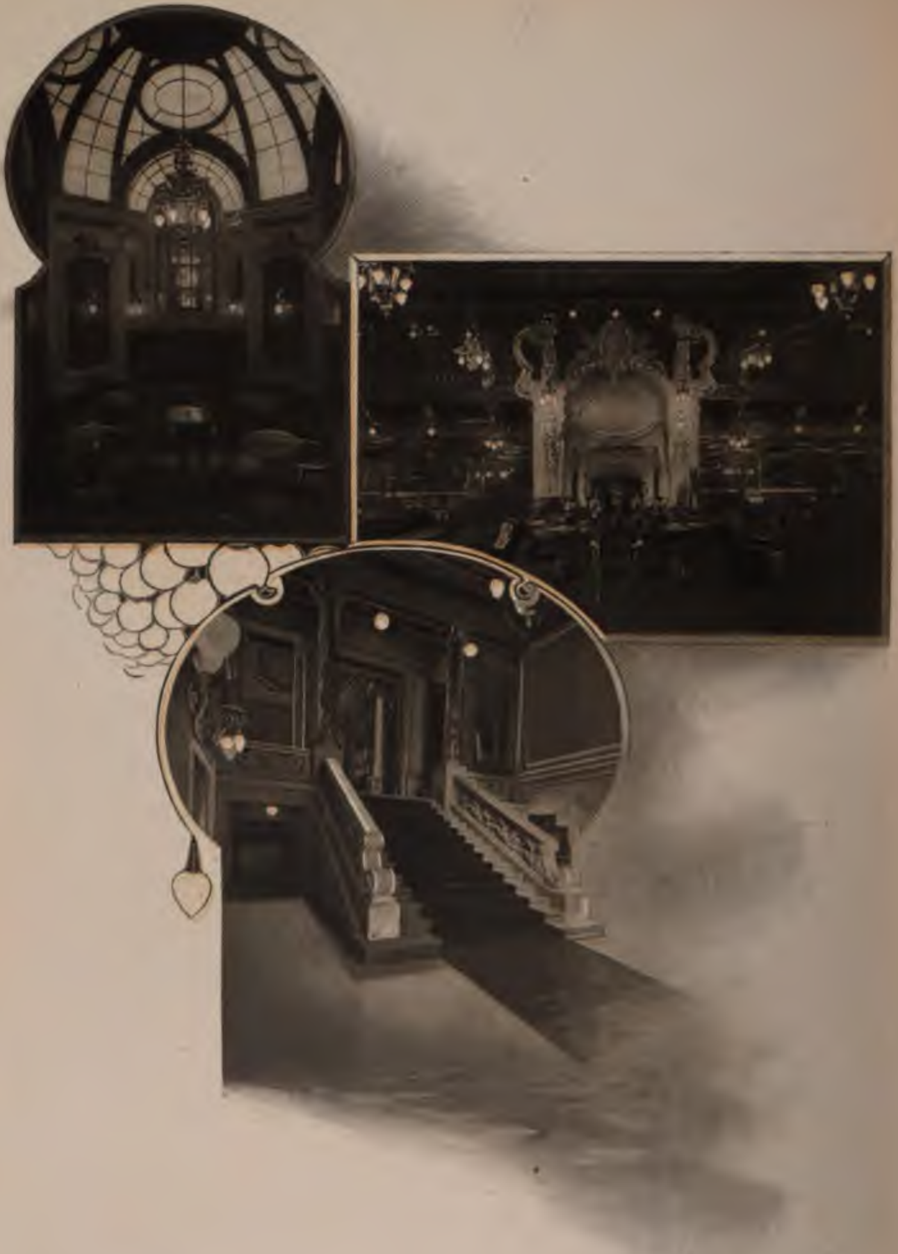


Curtain and Proscenium Arch of the Irving Place Theatre as arranged for the visit of Prince Henry of Prussia. The portraits of the German Emperor, his father and grandfather appear at the lower line of the permanent curtain. Courtesy of *The Eblight Company of America.*

darkness, it gave that entire section of the city an appearance of life that could not be otherwise obtained. Where is such another sight to be found as the vistas on our New York Broadway, looking in almost any direction in the evening hours, unless perchance in some of our other great electrical centers—Boston, Chicago, Philadelphia. The picture is artistic and interesting on a clear night, but in mist or rain all is greatly enhanced. These signs serve important commercial purposes; some, taken singly, may be anything but well designed or artistic, but taken altogether they give to the thoroughfare a wonderfully high degree of attractiveness.

Signs not only spell words, names or sentences, but serve the further purpose of illuminating the premises and the street, thereby giving a double value. The first is advertising, the second light; both are desirable, each has a definite commercial value, one is a necessity and in some form must be had at any price.

These features, beyond the mere giving of light, can be made of enormous commercial value in the electrical industry. One may not always find sufficient incentive to adopt electric light simply because of the difference in the quality of the light, but, adding convenience and cleanliness, features upon which I have not touched, and the further quality of artistic arrangement, alone or in conjunction with existing conditions, we have a combination that for health, comfort and satisfaction in living can hardly be equalled, much less surpassed. Decorative lighting, purely as such, is seldom remunerative, but it offers one of the best suggestions of the many uses of electric service and has probably never been undertaken on any large scale, and artistically, without starting a great many lines of thought to the benefit of the supplying company. Electric signs not only advertise their user, but, in the best sense, themselves. The installation of one sign on a dark block will lead

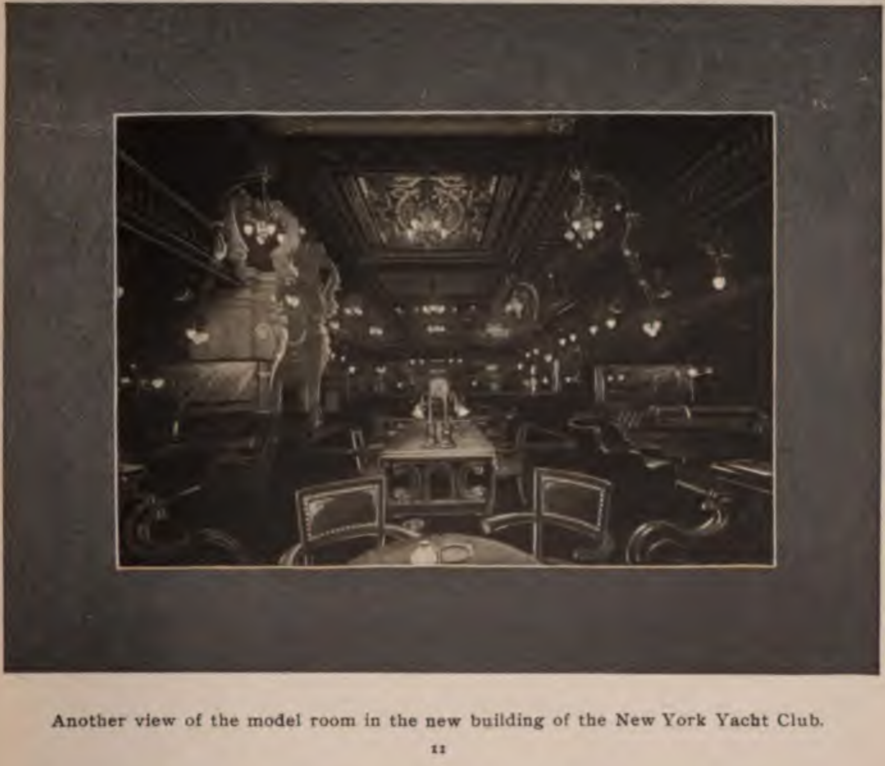


Main hall, model room and a corner in the smoking room of the new building of The New York Yacht Club. This is one of the most fully equipped and luxurious club houses in the country.

almost invariably to more signs or to better show windows and interior illumination. All of which is advertising—not lighting—primarily, and the lighting, being additional, practically doubles the normal revenues.

It is not the intent of this article to do more than suggest some of these possibilities, and the use of diagrams and figures has been intentionally avoided, but the annual revenue, which may be obtained from a single sign, if figured out, would probably cause surprise to a number of our members.

It would be tedious to our members were a technical description of the illustrations of this report attempted. The methods will be clearly evident to the technically informed, the use of a magnifying glass often assisting in obtaining the details. So far as possible, the notes contain our acknowledgments to those who have kindly loaned photographs and furnished information upon the subjects considered.



Another view of the model room in the new building of the New York Yacht Club.

About Lamps

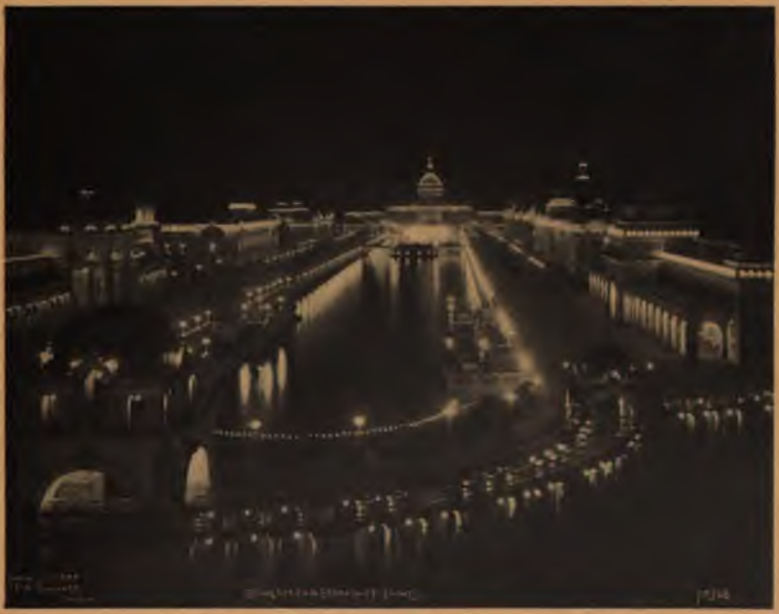
For sign illumination originally, plain or frosted lamps of 16 candles were largely used—but as the "use factor," if I may employ the term, averages 100%, and is of long duration, the cost of electric current limited, and in many instances entirely prevented, the use of signs of this type. There was no necessity for light units of that size and the practice soon changed to the general use of 8 candle lamps, and now even smaller sizes, such as 4, 5 and 6 candles are widely employed. Lamps of high efficiency, 3.1 watts per candle, are satisfactory for the larger sizes but it is desirable, if not necessary, to lower the efficiency, and thus increase the durability, to 3.5, 4 or 5 watts per candle where the smaller lamps are used.

Lamps of 16 candles consume approximately 50 watts; of 8 candles, 30 watts and of 4 candles, such as are recommended where 8 candles are not used, 20 watts. Were the life of each the same (the Company making the renewals) the renewal costs a kilowatt hour would almost double with lamps of 8 candles and become nearly three times with the 4 candle standard. In changing to the lower efficiencies, with corresponding increase in life, the Supplying Company obtains closely an even cost for lamp renewals, at any candle-power, and the lessened breakage rate means that fewer lamps are out of service simultaneously, and therefore is obtained a higher average or more even character of illumination throughout the sign.

Miniature lamps lend themselves especially well to artistic sign lighting, but first and renewal cost is high, and they are very much less efficient in the use of current than lamps made with standard filaments. Variation from standard sizes in filaments, as well as in bases, and the frequent use of several lamps in series, make it necessary for either the supplying Company to carry a special stock, or for the consumer to carry a larger stock than he would, could he obtain these lamps directly from the supplying

Company. It is questionable whether these differences justify the use of miniature lamps under other than unusual conditions.

What is said of signs is also true in large measure of decorative lighting, more especially where that lighting is permanent. Almost without exception 4 and 8 candle lamps are sufficient, the larger sizes being required only where illumination is the primary or at least an important consideration.



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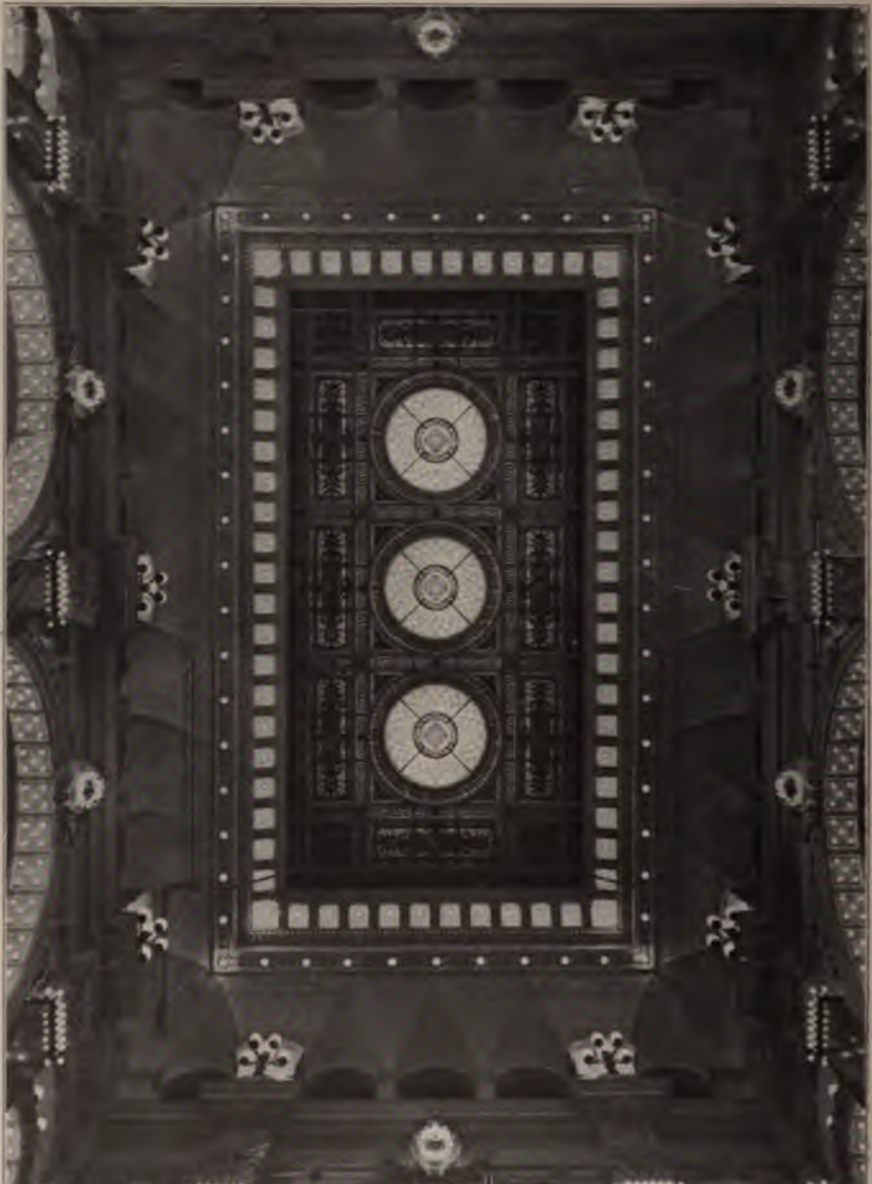
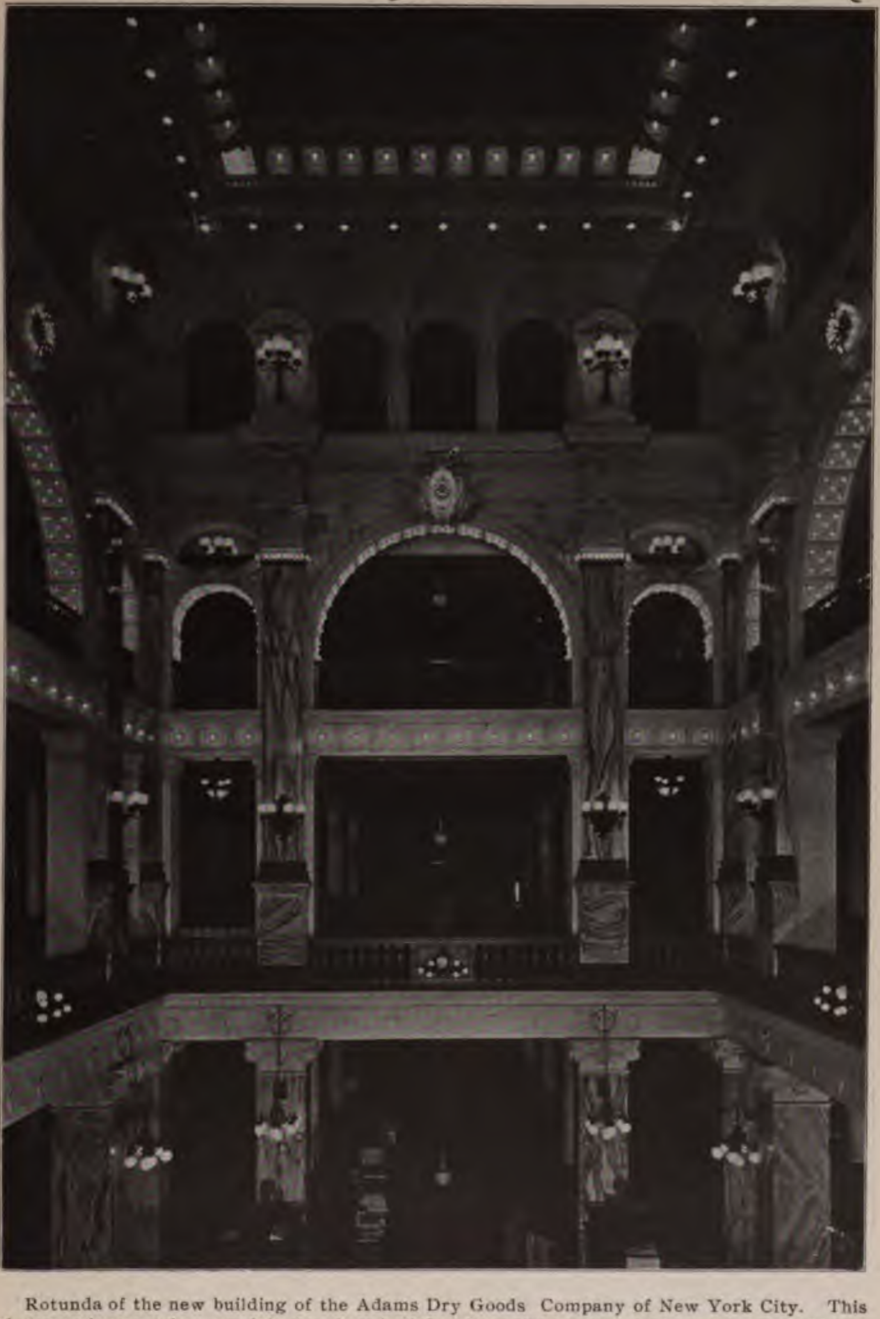
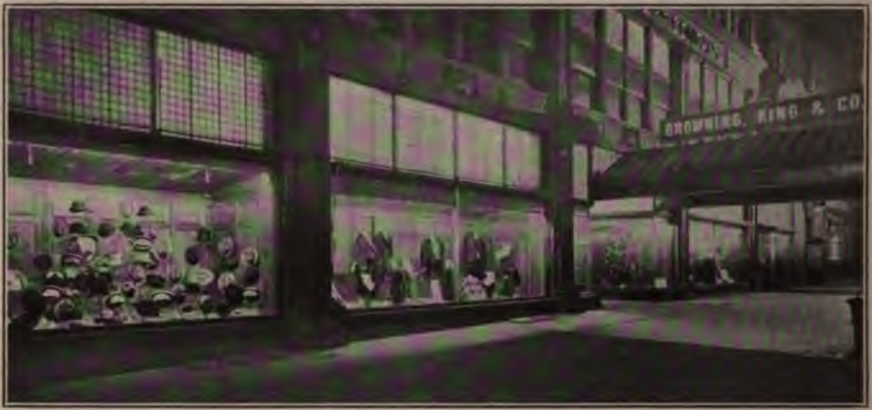
From a night photograph of the Grand Court at the Omaha Exposition. The electrical effects were produced by Luther Stieringer. 1898.



Dome of the rotunda of the new building of the Adams Dry Goods Company, New York City, taken from below. The center panel is of stained glass with incandescent lamps above.

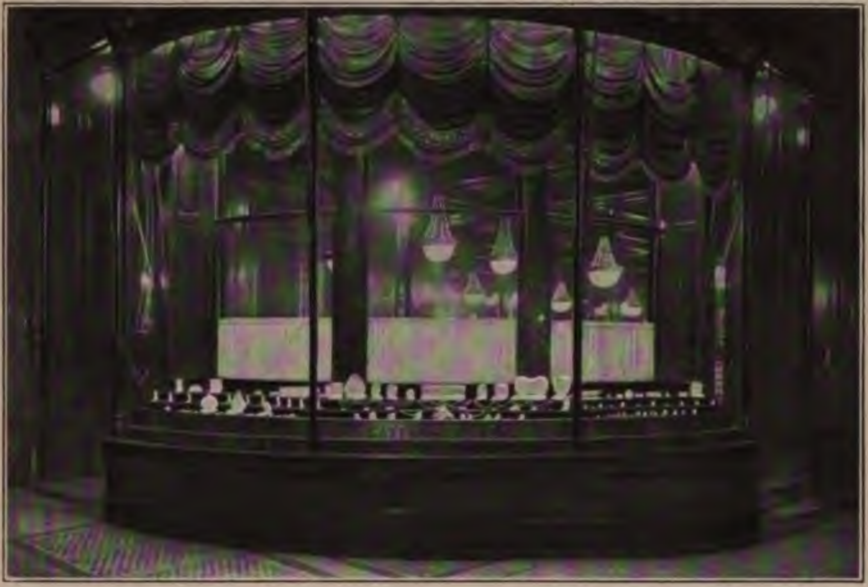


Rotunda of the new building of the Adams Dry Goods Company of New York City. This photograph was taken at night by electric light. Reproduced through the courtesy of Harry Alexander, by whom the installation was made.

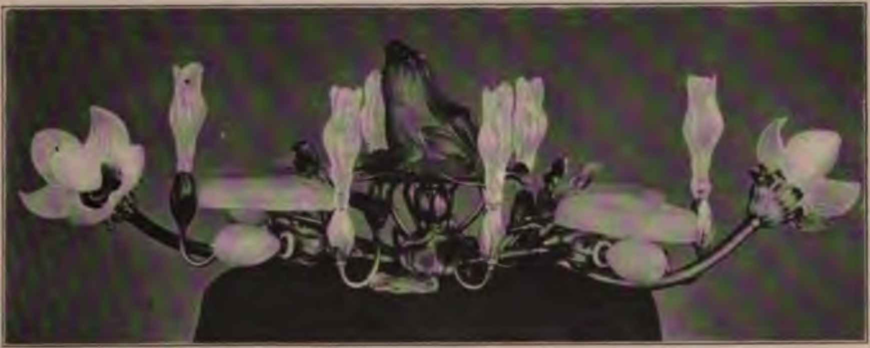


One of the most striking show windows in New York City. The illumination is obtained from hidden incandescent lamps. Taken from a night photograph. From the *Bulletin of the New York Edison Company.*

A large department store in Chicago. Attention is drawn to the clearness with which the outlines of the buildings have been reproduced. Through the courtesy of *The Chicago Edison Company*



A Fifth Avenue show window in New York City. The incandescent lamps are at the top and the source of light is hidden by the lowered curtain.

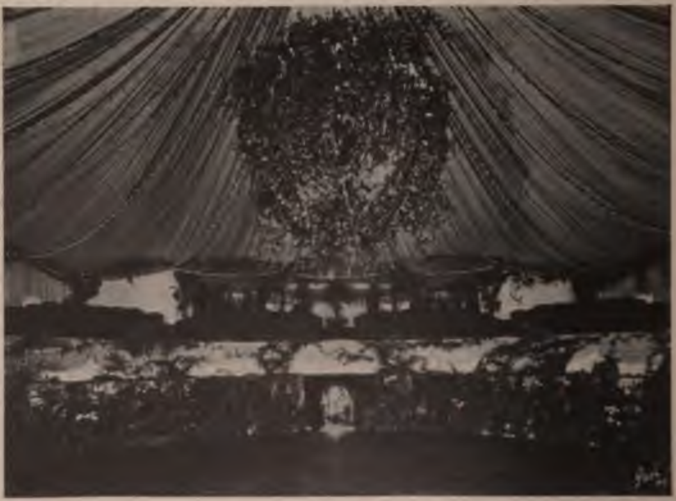


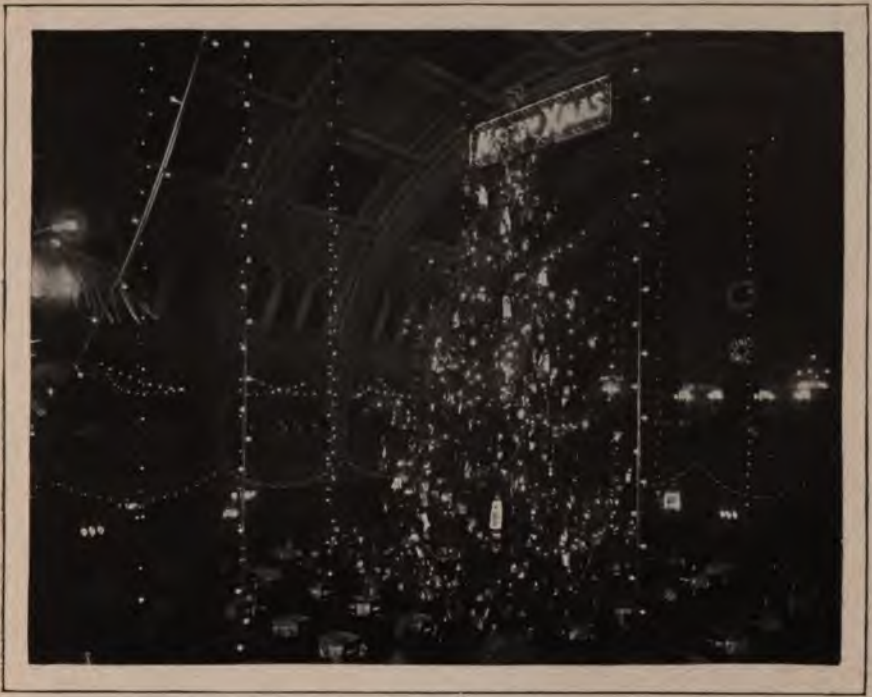
A new design for ornamental table lighting. Courtesy of *The Mitchell Vance Company.*

ELECTRIC TOWER.

An electric fountain and tower of light at Coney Island. Reproduced through the courtesy of the *Edison Electric Illuminating Company of Brooklyn.*

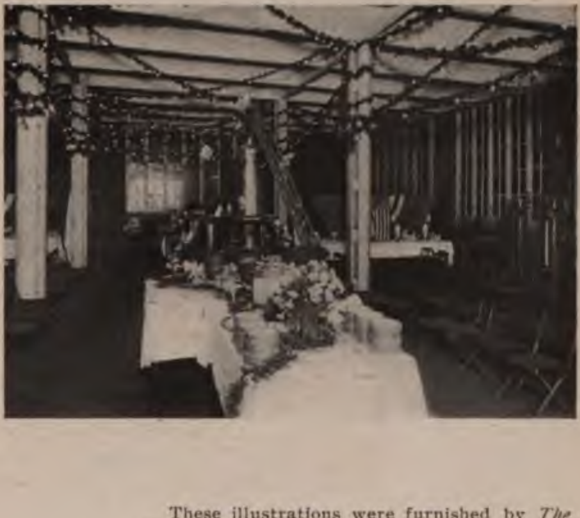
Very effective ceiling and wall decorations, consisting principally of smilax, ferns and electric lights. Courtesy of *The Eblight Company of America.*





Christmas Eve at Pabst's in Harlem. One of the largest Christmas trees ever erected. Electric lights were placed profusely throughout the auditorium and around the walls.

Temporary illumination for a recent meeting at Stevens Institute, Hoboken, N. J.

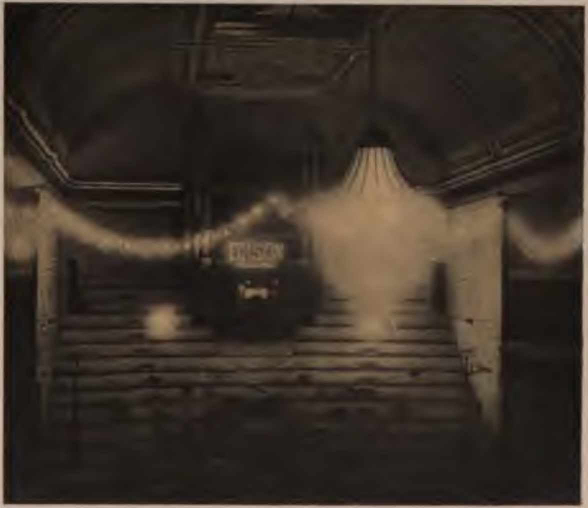


These illustrations were furnished by *The Ehlight Company of America.*

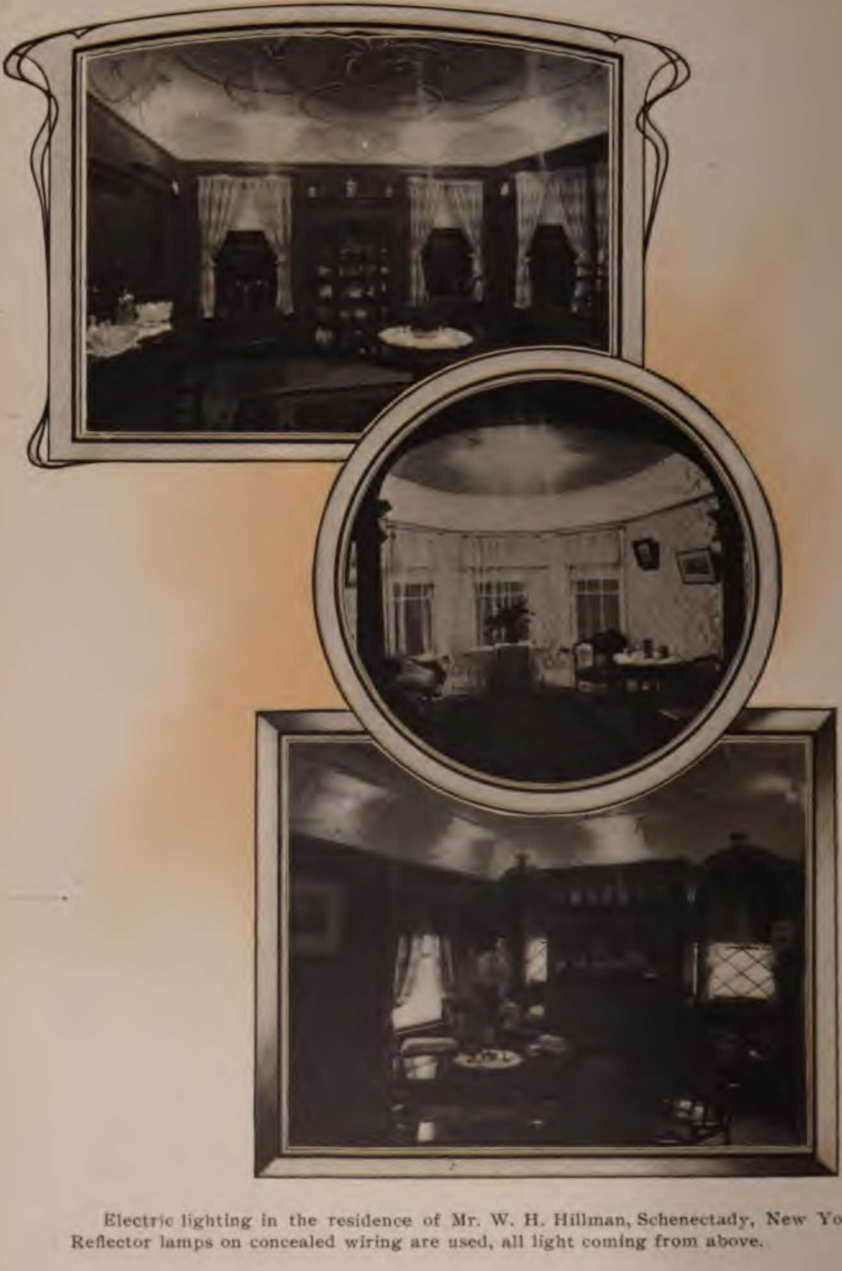
Booth of the New York Edison Company in the Electrical Show, held at Madison Square Garden, in 1898. Designed by J. Van Vleck.

A home altar for a wedding ceremony.

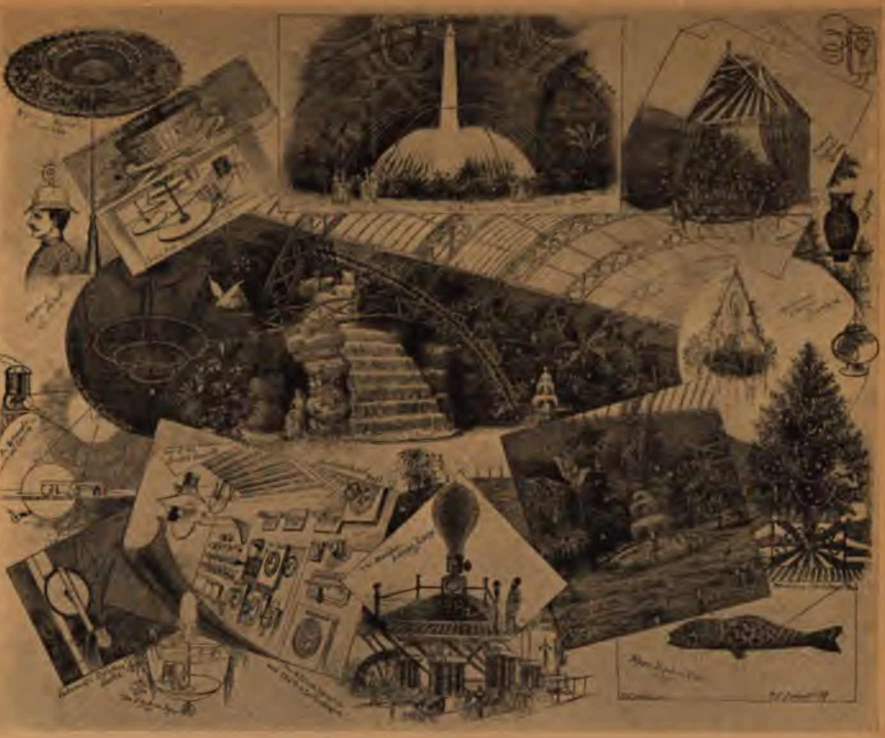
Courtesy of *The Eblight Company of America.*



The first electric sign. Designed and constructed by William J. Hammer, Chief Engineer of the English Edison Company, and placed on the organ in the Concert room at the Crystal Palace, during the International Electrical Exhibition of 1882. The name "Edison" was flashed out by means of a spring switch. This, the lighting by festoons and the crystal chandelier, were part of the Exhibit of 1,500 incandescent lamps installed by the English Edison Company.



Electric lighting in the residence of Mr. W. H. Hillman, Schenectady, New York
Reflector lamps on concealed wiring are used, all light coming from above.



Novel electrical displays constructed for the Centennial Exposition of the Ohio Valley and Middle Atlantic States, held at Cincinnati, Ohio, July 4 to October 27, 1888, reproduced by permission of William J. Hammer, Consulting Engineer to the Exposition. More than 20,000 Edison incandescent lamps were used.

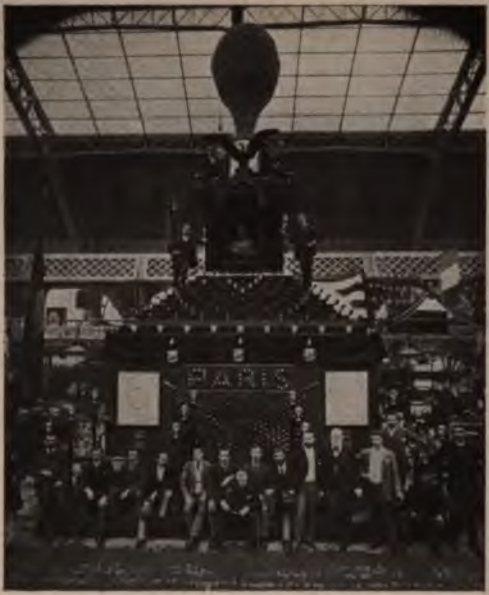
In the Electrical Cascade 7,200 gallons of water passed every minute over a bed of electric fire, constantly changing color and scintillating The rainbow spanning the Falls frequently changed color, flashed lightning, slowly faded away and reappeared. Hundreds of colored lamps filled the sixteen pedestal baskets of tropical plants, and lined the gardens and pathways. Four crystal fountains threw colored sprays amongst the rockwork, vines and mosses. Tiny stars, moons and crescents could be seen shining and twinkling, owls perched among the rocks and branches and winked their electric eyes solemnly. Far overhead, hanging by a single wire, was a mysterious electric fountain, from which a jet of water was thrown high in the air; the larger fountain also shown, threw a jet 100 feet high, with many lesser jets below under the steel rods, which carried hundreds of colored lights. Eight magic Japanese fishes, thirty feet in length, filled with incandescent lamps, hung in the main aisle, were connected by a commutator, one after the other, giving the appearance of a large fish swimming down the main aisle of the Exposition and disappearing into the big fountain.

The tropical garden weighed 4½ tons, and carried on its several tiers tropical plants with many glass flowers containing colored electric lamps operated on eighteen sets of circuits. As the garden was rotated by an electric motor the flowers bloomed and changed colors amongst the tropical foliage.

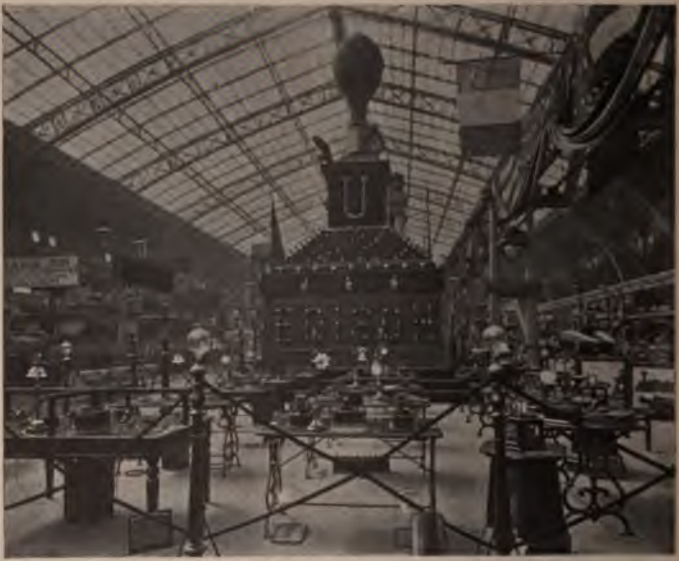
The electric Christmas tree was 40 feet high, and on the base were the Centennial emblems and dates which automatically flashed and scintillated as the tree revolved.

Other electrical features included Revolving Japanese Umbrellas and attendants with electric lamps in their helmets which lit periodically as they walked around the Exposition floors.

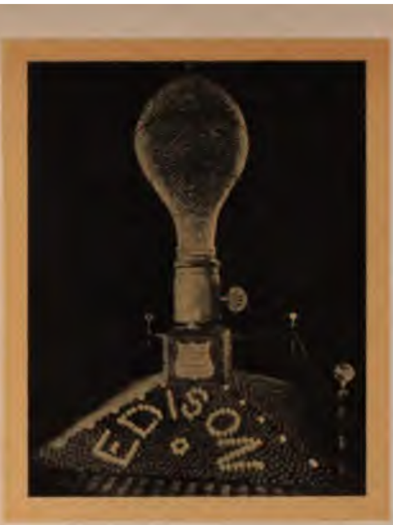
A 250 H. P. Corliss engine, four huge Edison dynamos and eight electric motors were used in this important installation.



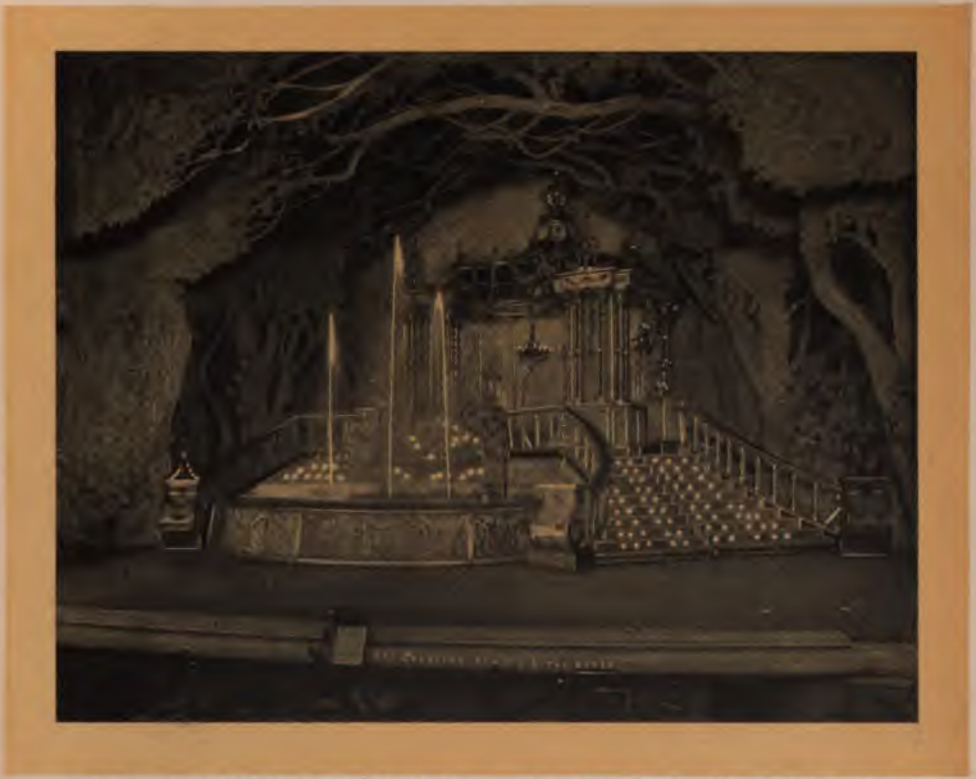
Front of the Mammoth Edison Lamp at the Paris Exposition of 1889. The American and French flags, made of colored Edison lamps, were turned up and down and made to wave and flash while the word "Paris," the figures "1889" and Mr. Edison's name (appearing on the side) were lit up, the light running up and down the pedestal to the niche containing the bust of Mr. Edison, the American Eagle and the huge lamp at the top. The illustration also shows Mr. Edison's representative, Mr. William J. Hammer and his assistants. The Lamp utilized 25,000 incandescent bulbs, many miles of wire, and was 45 feet in height.



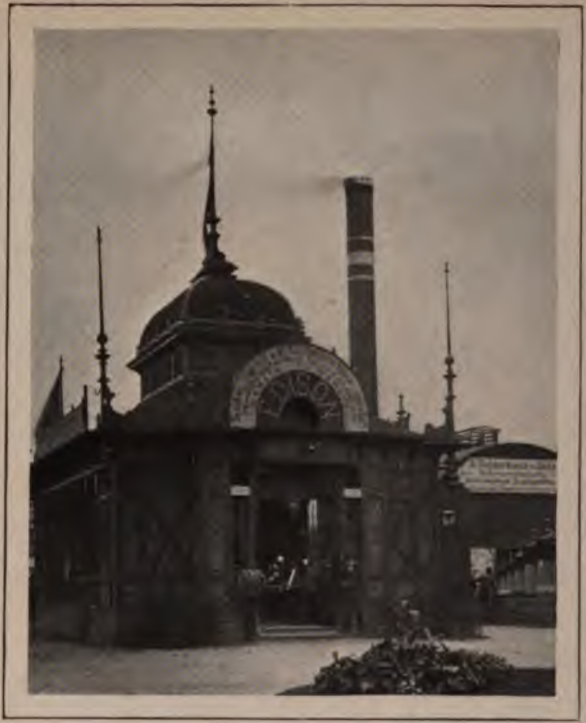
Showing one of the seventeen departments of Edison's Exhibit at the Paris Exposition of 1889, the largest exhibit in the Exposition. Back of the Telegraph Section is shown the hugh Edison Lamp which, with its pedestal, stood 45 feet high and employed 25 000 Edison incandescent bulbs—the daily output at that time of the Edison lamp factory. Inside the base were switches, rheostats, automatic controllers, etc., for operating the lamps, the United States and Republic of France emblems, the waving French and American flags and Edison's name.



Huge Edison Lamp, made of 15,000 incandescent bulbs, exhibited at the Cincinnati Centennial Exhibition, in 1888. Designed and constructed by and reproduced through the courtesy of William J. Hammer, Consulting Engineer to the Exhibition.



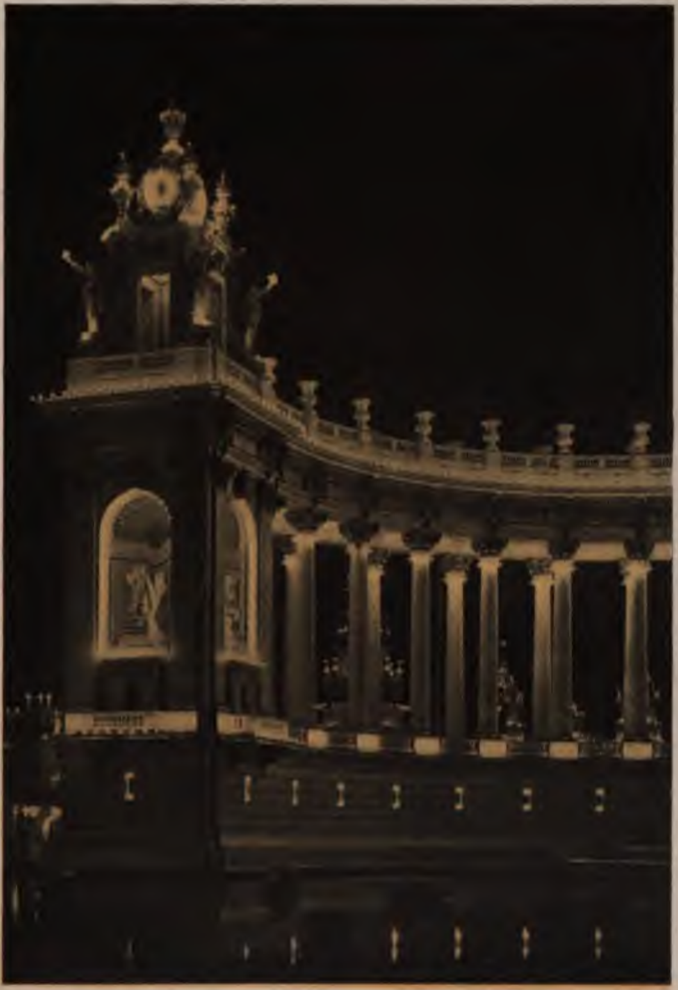
Stage setting of the last scene of "The Beauty and the Beast" as reproduced at the Broadway Theatre, New York City. Courtesy of *The Eblight Company of America.*



The Edison Pavilion of the German Edison Company, (now the Aliegemeine Elektricitats Gesellschaft), at the Health Exhibition in Berlin, in 1883. The electric sign was flashed letter by letter, and as a whole by an automatic commutator driven by an electric motor. Designed and constructed by the Company's chief engineer, at that time, William J. Hammer, through whose courtesy it is reproduced. This is the first automatic electric sign constructed.

Copyright, C. D. Arnold, 1903.

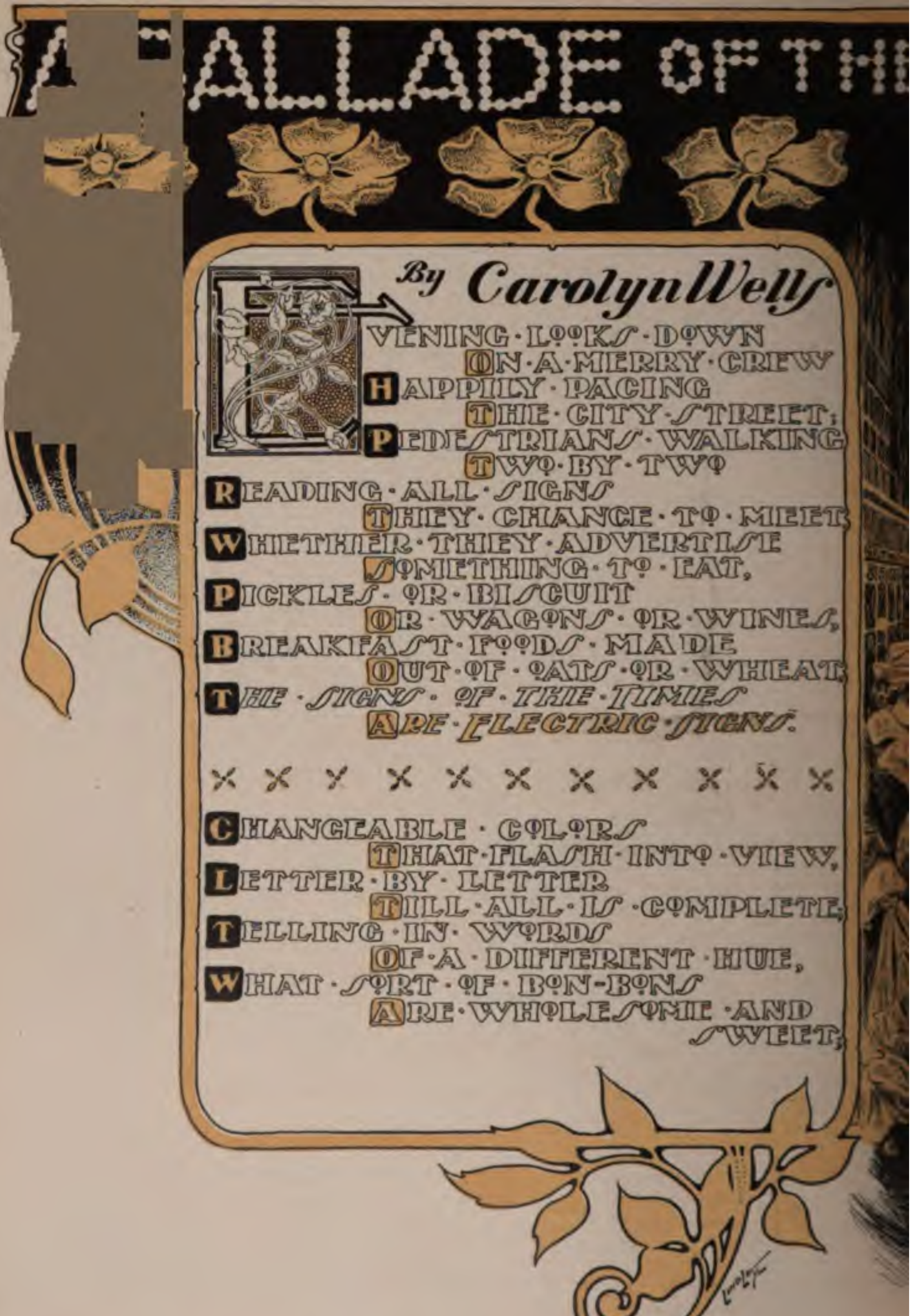
The Pan-American, 1901.



The Pan-American, 1901. Copyright, C. D. Arnold, 1903.

It is gratifying to note that Mr. Stieringer's work at the Pan-American has recently been recognized by the Franklin Institute in conferring upon him the John Scott Legacy Medal and Premium.

Without detracting in any sense from the work of others, including that of Mr. Henry Rustin, under whose charge the effects were produced, the credit for the original scheme and the underlying ideas, which marked a new epoch in decorative treatment, must go to Luther Stieringer.



[redacted]ALLADE OF TH

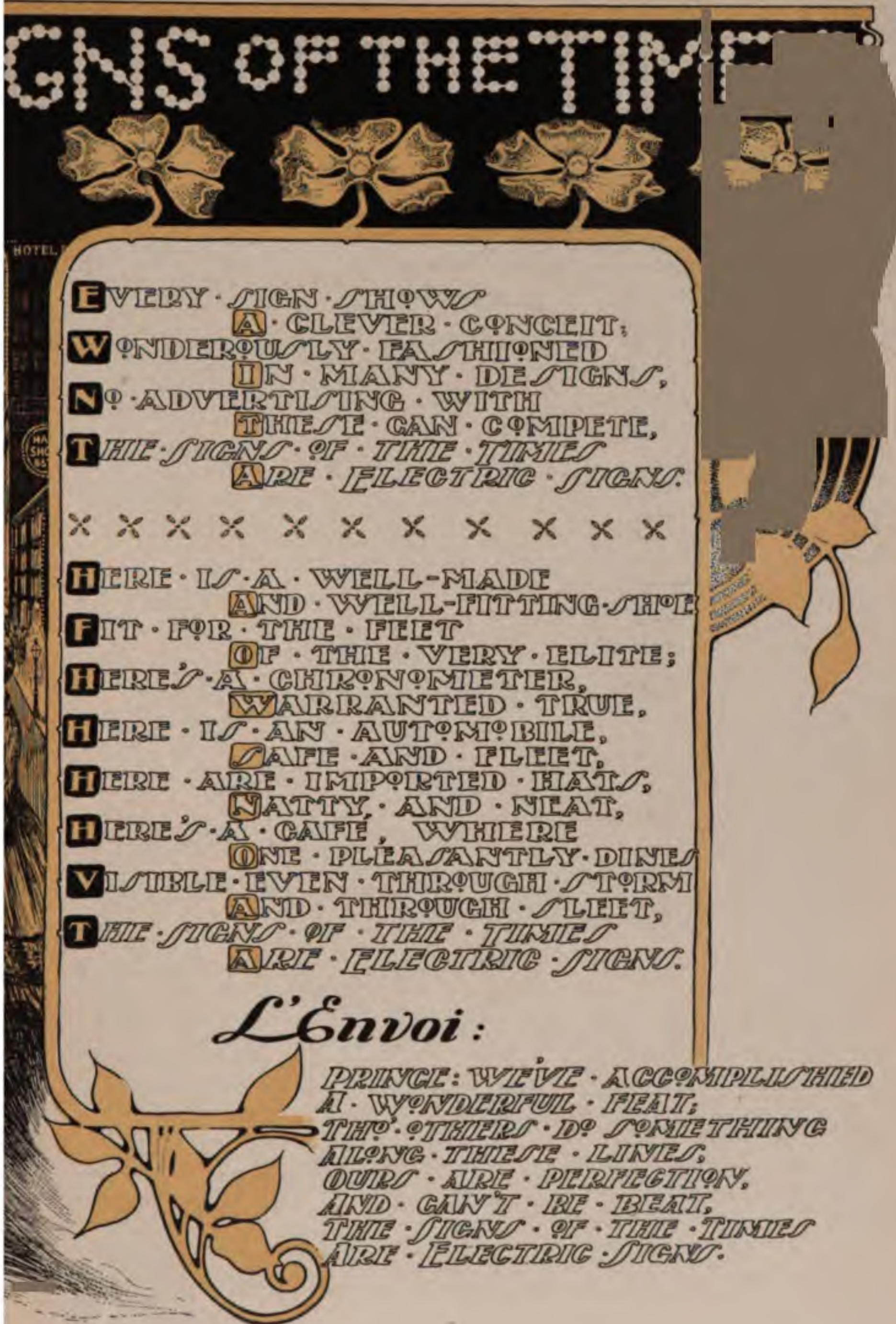
By Carolyn Wells

EVENING · LOOKS · DOWN
ON · A · MERRY · CREW
HAPPILY · PACING
THE · CITY · STREET;
PEDESTRIANS · WALKING
TWO · BY · TWO
READING · ALL · SIGNS
THEY · CHANCE · TO · MEET
WHETHER · THEY · ADVERTISE
SOMETHING · TO · EAT,
PICKLES · OR · BISCUIT
OR · WAGONS · OR · WINES,
BREAKFAST · FOODS · MADE
OUT · OF · OATS · OR · WHEAT,
THE · SIGNS · OF · THE · TIMES
ARE · ELECTRIC · SIGNS.

× × × × × × × × × × ×

CHANGEABLE · COLORS
THAT · FLASH · INTO · VIEW,
LETTER · BY · LETTER
TILL · ALL · IS · COMPLETE,
TELLING · IN · WORDS
OF · A · DIFFERENT · HUE,
WHAT · SORT · OF · BON-BONS
ARE · WHOLESOME · AND
SWEET;

Reproduced from the *Bulletin of The New York Edison Company.*



GNS OF THE TIM[redacted]

EVERY · SIGN · SHOWS
A · CLEVER · CONCEIT;
WONDEROUSLY · FASHIONED
IN · MANY · DESIGNS,
NO · ADVERTISING · WITH
THESE · CAN · COMPETE,
THE · SIGNS · OF · THE · TIMES
ARE · ELECTRIC · SIGNS.

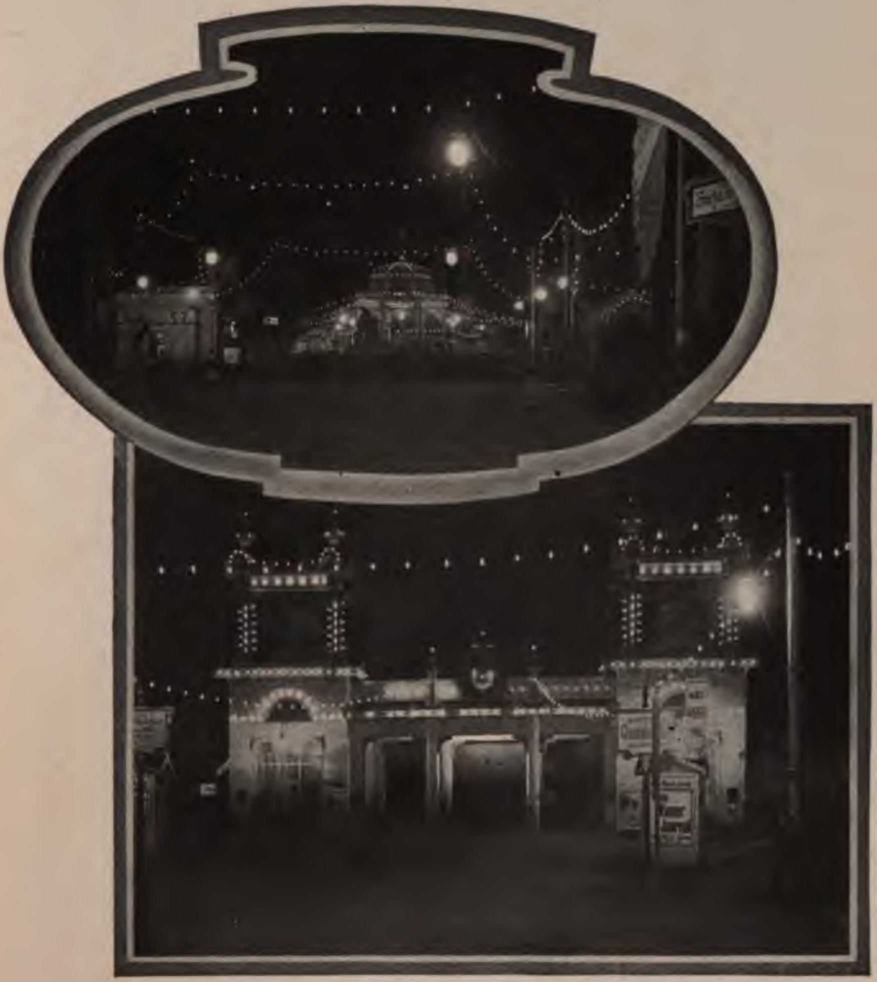
× × × × × × × × × × ×

HERE · IS · A · WELL-MADE
AND · WELL-FITTING · SHOE
FIT · FOR · THE · FEET
OF · THE · VERY · ELITE;
HERE'S · A · CHRONOMETER,
WARRANTED · TRUE,
HERE · IS · AN · AUTOMOBILE,
SAFE · AND · FLEET,
HERE · ARE · IMPORTED · HATS,
NATTY, · AND · NEAT,
HERE'S · A · CAFÉ, WHERE
ONE · PLEASANTLY · DINES
VISIBLE · EVEN · THROUGH · STORM
AND · THROUGH · SLEET,
THE · SIGNS · OF · THE · TIMES
ARE · ELECTRIC · SIGNS.

L'Envoi:

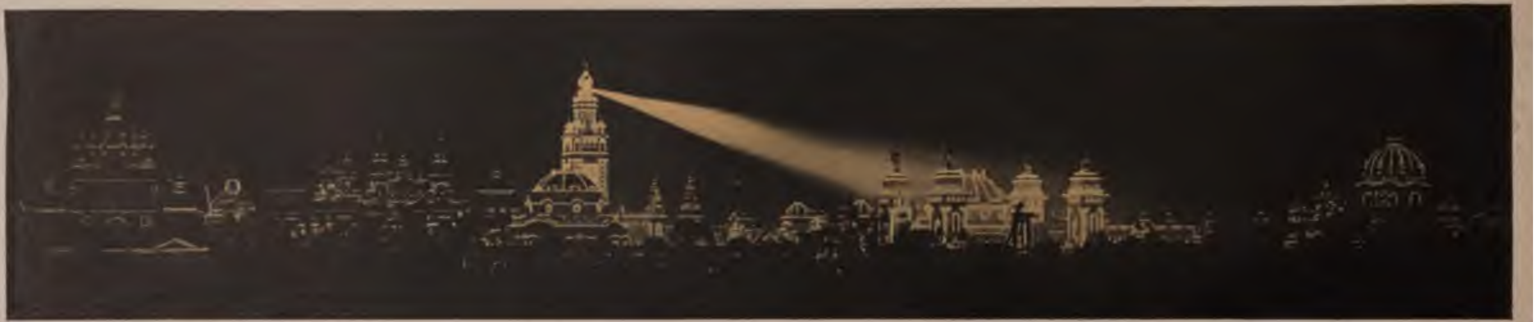
PRINCE: WE'VE · ACCOMPLISHED
A · WONDERFUL · FEAT;
THO' · OTHERS · DO · SOMETHING
ALONG · THESE · LINES,
OURS · ARE · PERFECTION,
AND · CAN'T · BE · BEAT,
THE · SIGNS · OF · THE · TIMES
ARE · ELECTRIC · SIGNS.

Vienna, 1898.



Showing the use of incandescent lamps for decorative effects at the Exposition in Vienna, Austria, in 1898.

Attention is drawn to the foliage effects in the lower photograph on the opposite page.



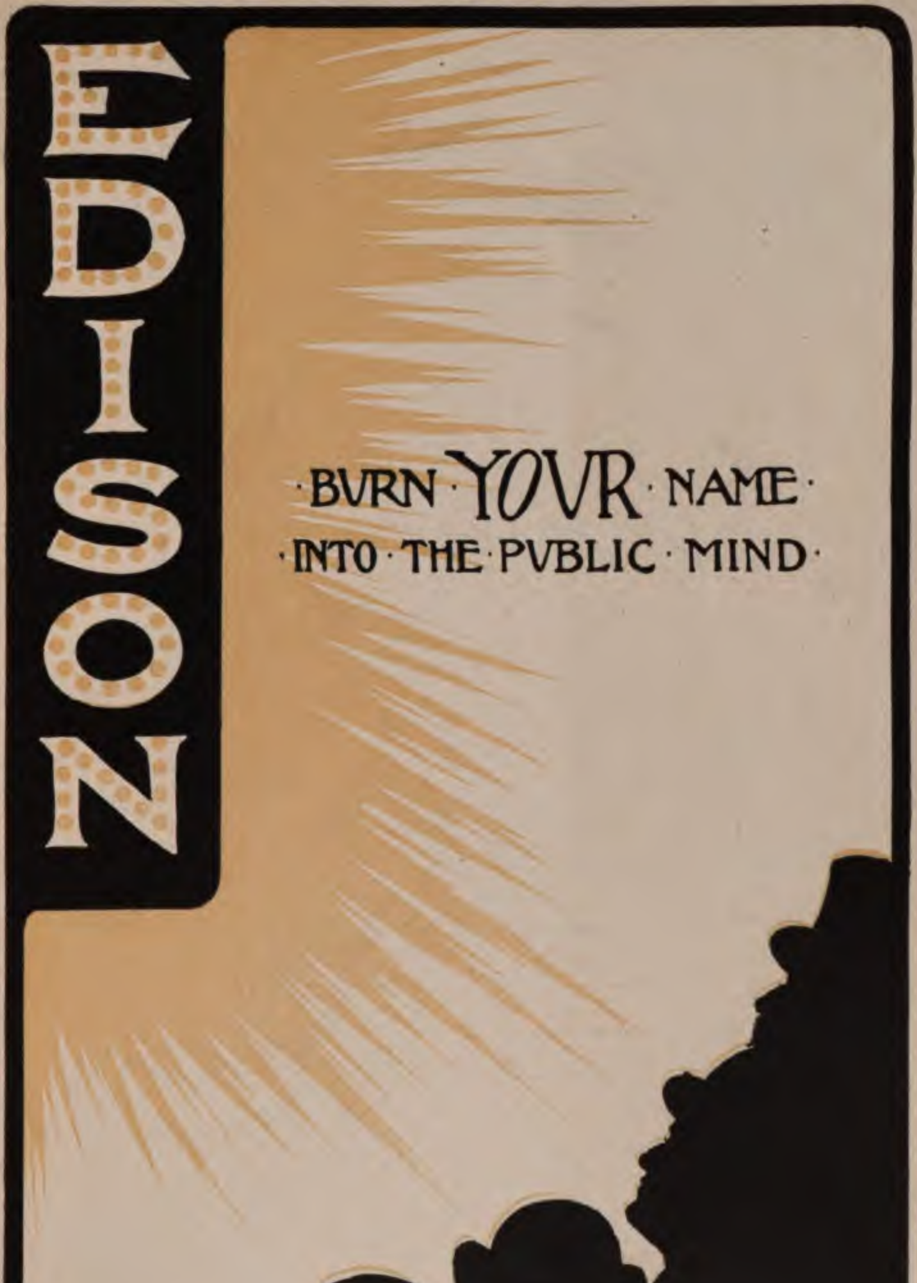
Through the courtesy of J. W. Lieb, Jr.

Even this view of the Pan-American, greatly enhanced by the search-light from the Electrical Tower, gives but slight conception of its wondrous beauty, when in the twilight the lamps increased from the first redness of the filament to the brilliancy of full candle power. The buildings literally were "bathed in light."

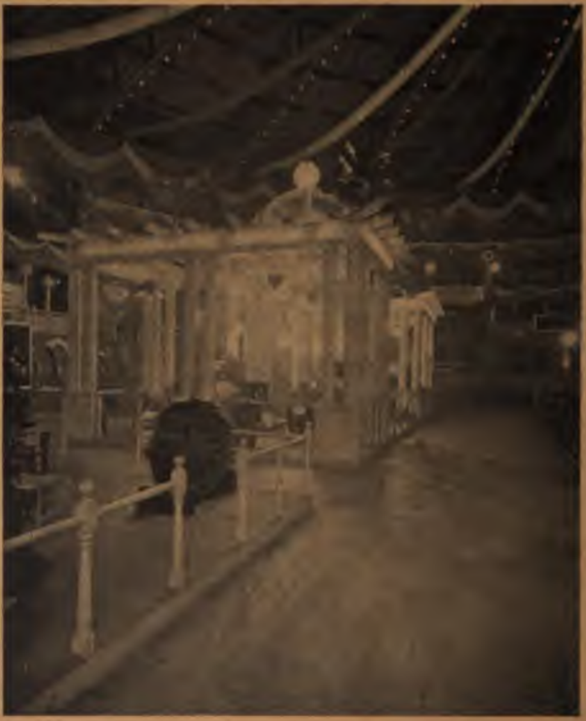
It was while looking upon this scene that Edison made the remark that, the medium through which this wondrous illumination was obtained, the filaments of the incandescent lamps, could all be held in one's hat.

Those who think the value of electric light for advertising, as well as decorative purposes, is over-estimated, have but to imagine this picture without the electrical effects.

It is not too much to say that without electricity the Pan-American could not have been, and that without Stieringer, the Pan-American would not have been what it was.



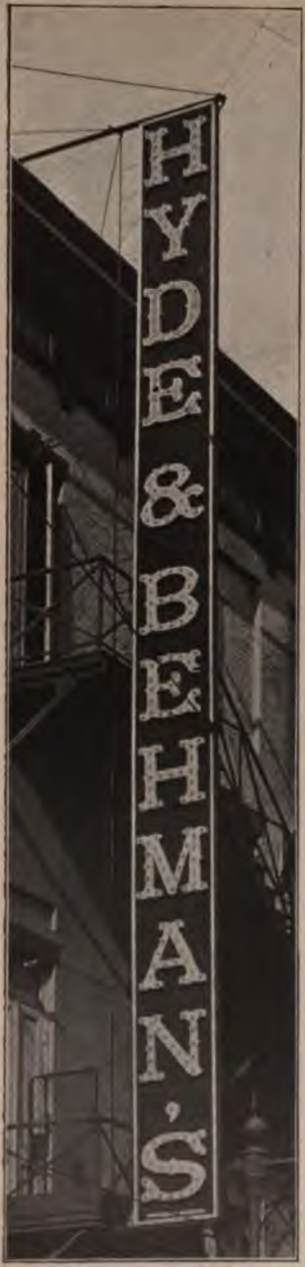
An effective cover for sign advertising. Reproduced through the courtesy of *The Edison Electric Illuminating Company of Brooklyn.*



This second view of the Edison Exhibit at The New York Electrical Show in 1898 is given for the purpose of showing the evening effects—and to enable one to value more closely the electric light for exhibition purposes.

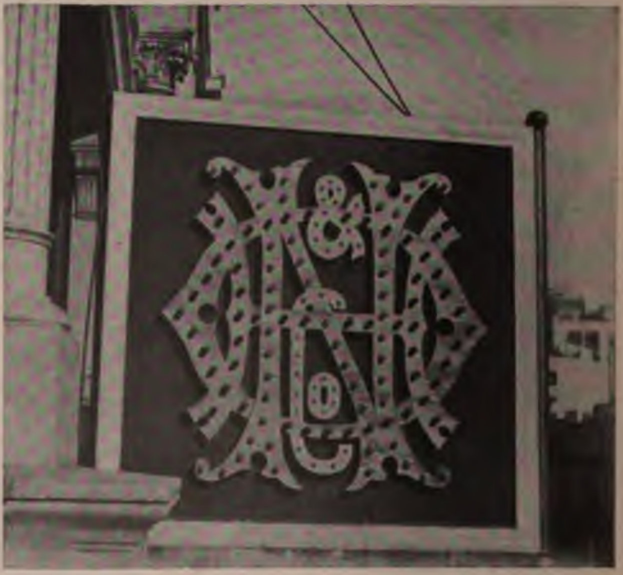
A familiar signature formerly on Broadway at Twenty-sixth Street, New York City.

The Harlem office of The New York Edison Company. The sign was built by the Metropolitan Engineering Company under patents recently granted.

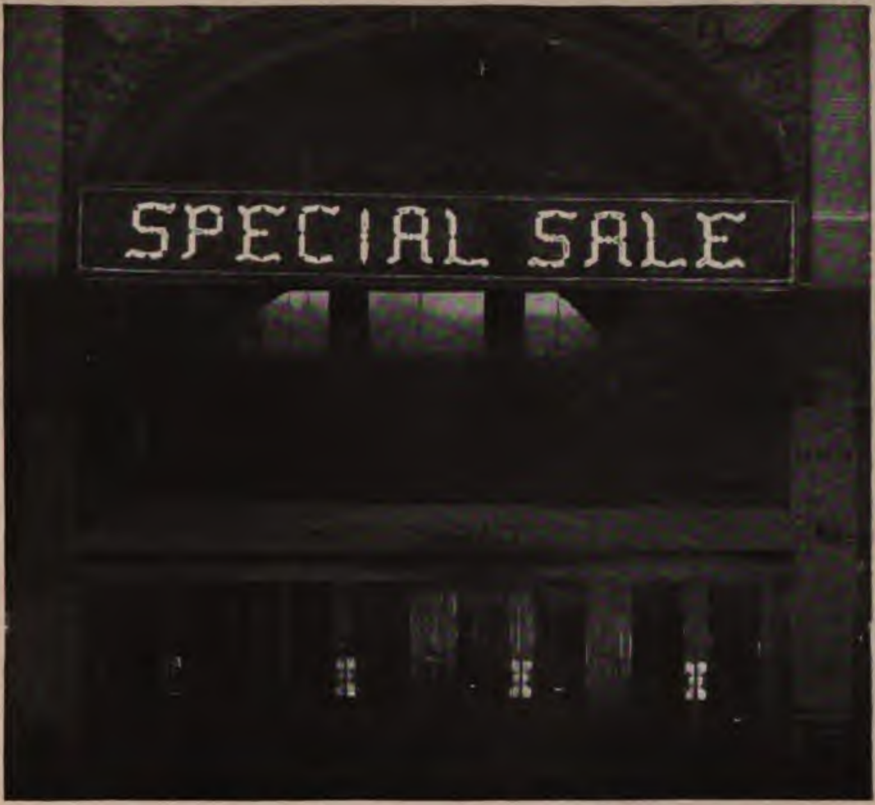


An effective sign for day as well as night purposes. The letters are in duplicate, appearing on both sides, and may be seen plainly at a great distance. Through the courtesy of *The Edison Electric Illuminating Company of Brooklyn.*

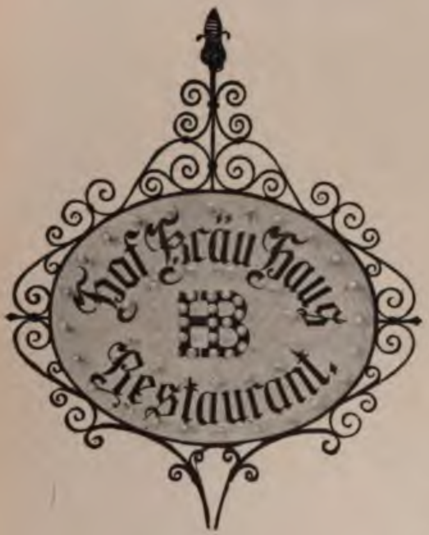
An artistic fixture.



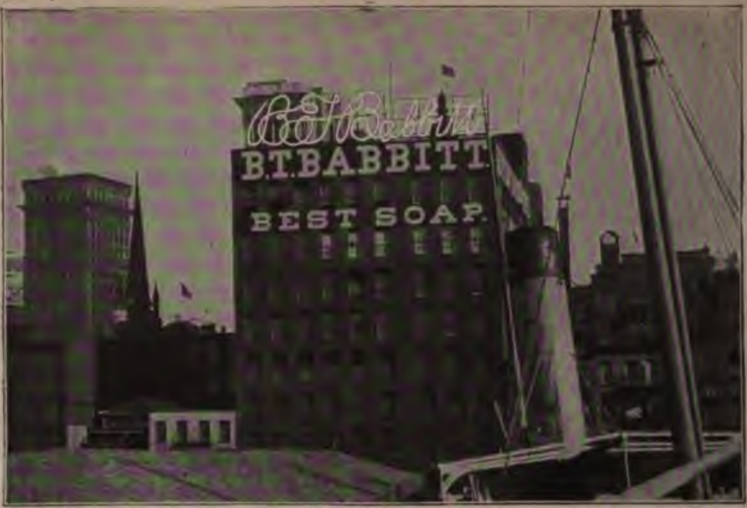
A monogram sign. Each letter may be shown in a different color.



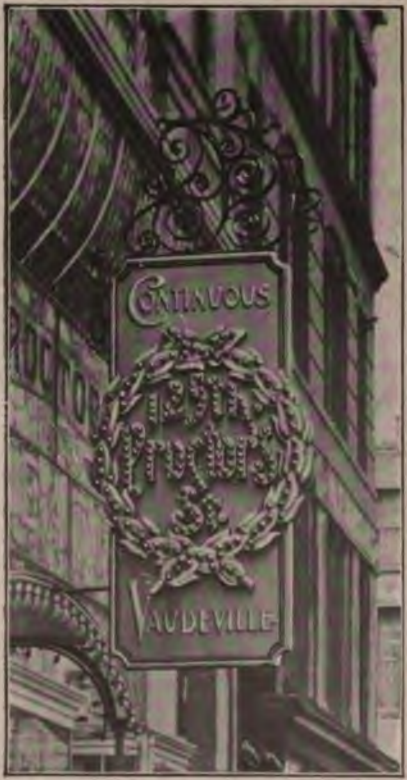
A Mason Monogram Sign used on one of the large department stores in New York City. This sign spells out almost instantly different words and sentences—the limit of length being only the extent to which the length of the sign itself is limited.



An artistic sign on a New York restaurant. Incandescent lamps in the monogram and following the lines of the letters give a striking night effect.

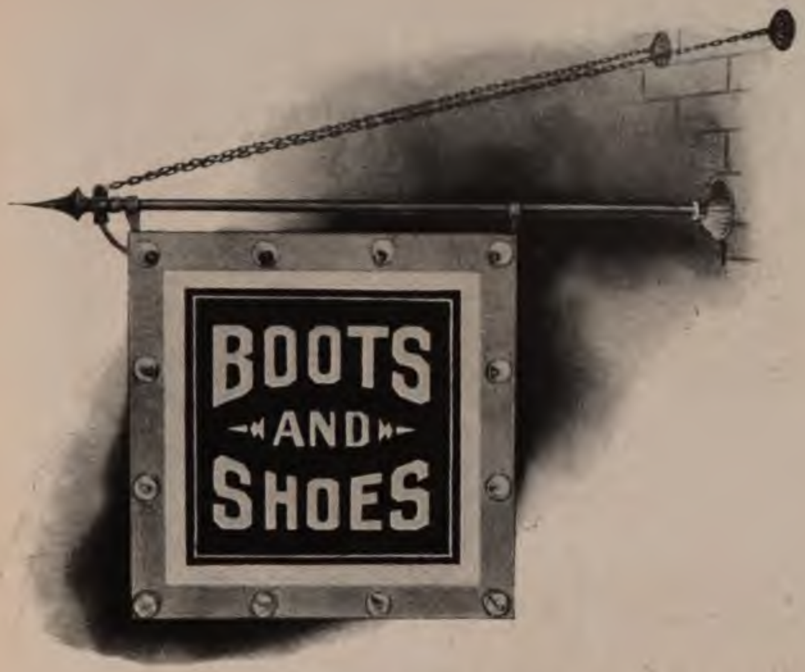


A sign of large size, with which all travelers on the North River are familiar. While the cut itself is poor there is no design more effective for the purpose it seeks to accomplish.

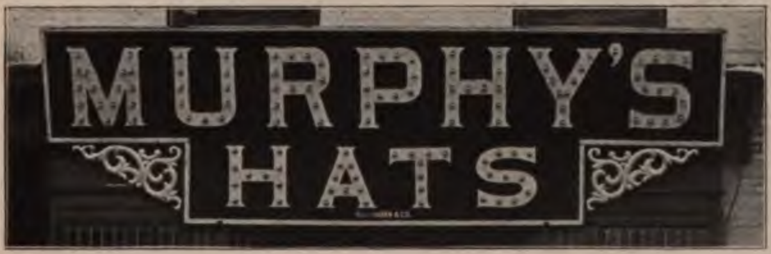


A characteristic Proctor sign. Lamps of green glass illuminate the wreath, red glass the interior and white the letters above and below.

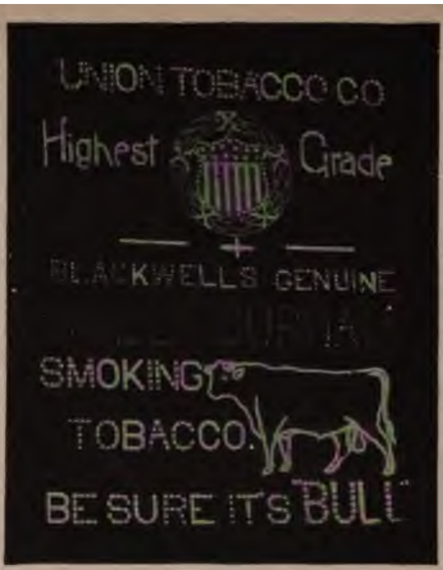
The extent to which Mr. Proctor uses electric light for advertising, as well as for illumination, indicates his belief in electric light, and to its use is undoubtedly due at least part of the marvelous success of his undertakings.



One of the Federal Electric Company's signs. The center panel is usually of blue enamel with letters of white. Incandescent lamps around the border produce striking night effects. Through the courtesy of *The Edison Electric Illuminating Company of Brooklyn.*



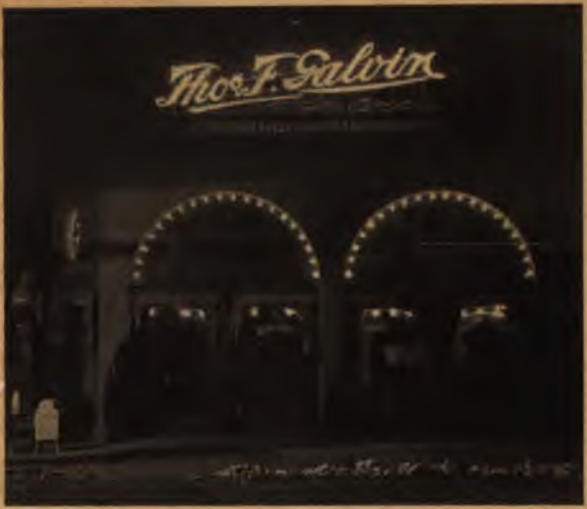
One effective method of using incandescent lamps in block letters. The letters are mounted on the sign board before erection.



A familiar sign effectively reproduced with electric lamps. Through the courtesy of Max Loewenthal.

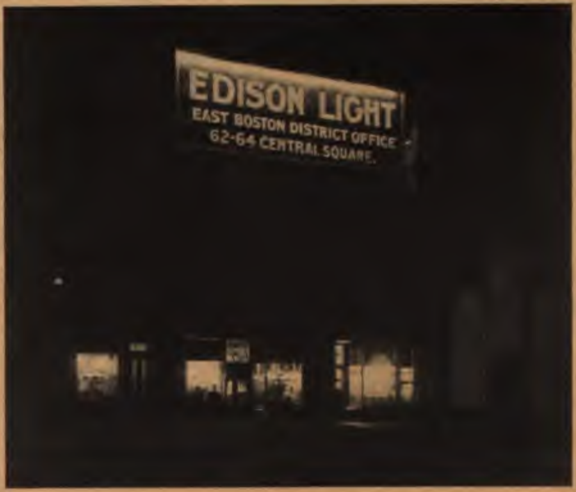
Show window illumination on a corner in Chicago. Through the courtesy of *The Chicago Edison Company.*

A corner on Boylston Street, Boston. Through the courtesy of *The Edison Electric Illuminating Company of Boston.*

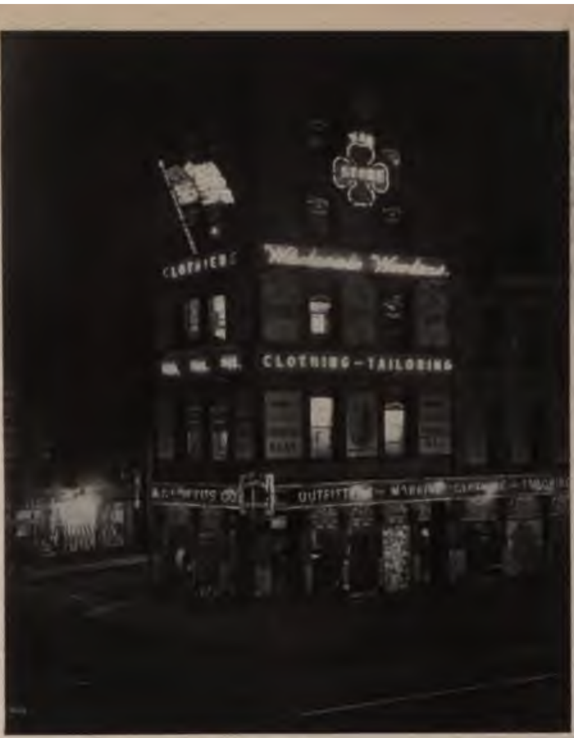


A very effective and artistic corner in Boston.

Through the courtesy of *The Edison Electric Illuminating Company of Boston.*



One of several signs employed by The Edison Electric Illuminating Company of Boston. The illumination is obtained from a row of concealed lamps behind a polished reflector at the top of the sign.

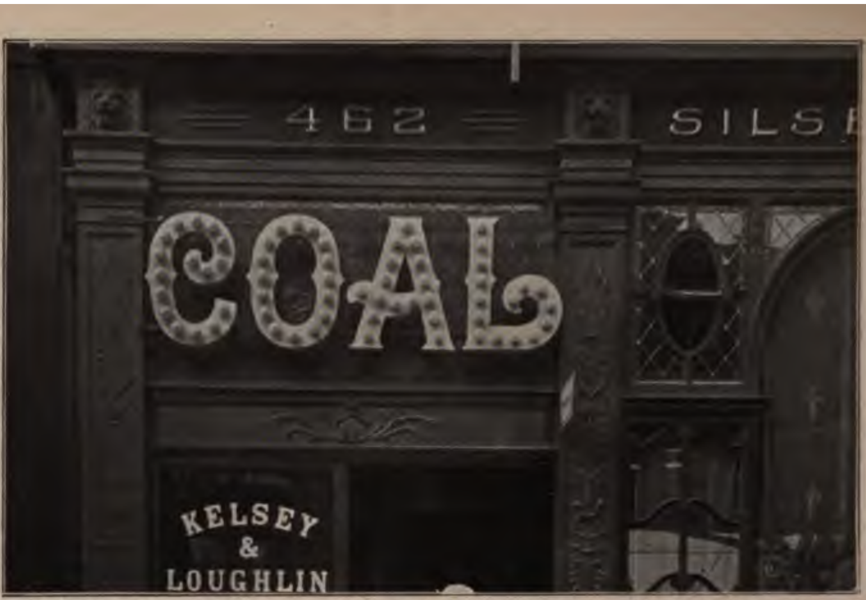


A strikingly brilliant corner in Boston. The flag, which is in its correct colors, appears to wave as though under the influence of a breeze. Through the courtesy of *The Edison Electric Illuminating Company of Boston.*

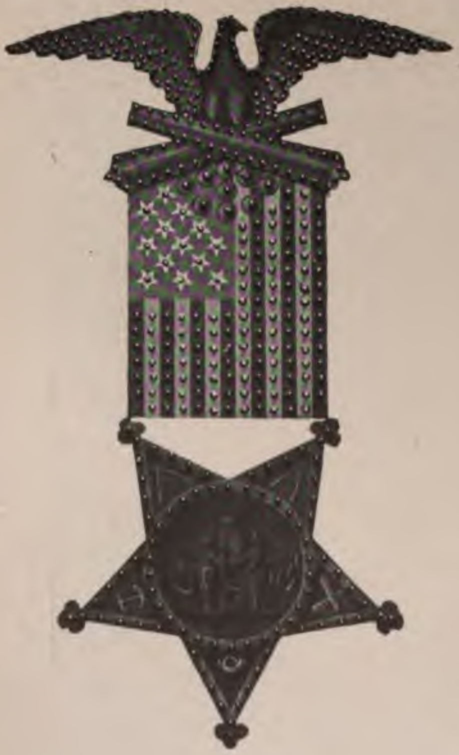
A poor photograph but an effective sign.

The building of the Arion Club, New York City, decorated for the visit of Prince Henry of Prussia. Courtesy of *The Eblight Company of America*.

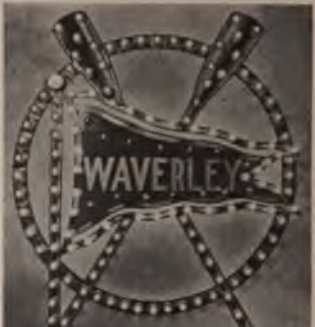
Effective Church illumination on the Eblight System, for Christmas, Easter or weddings.



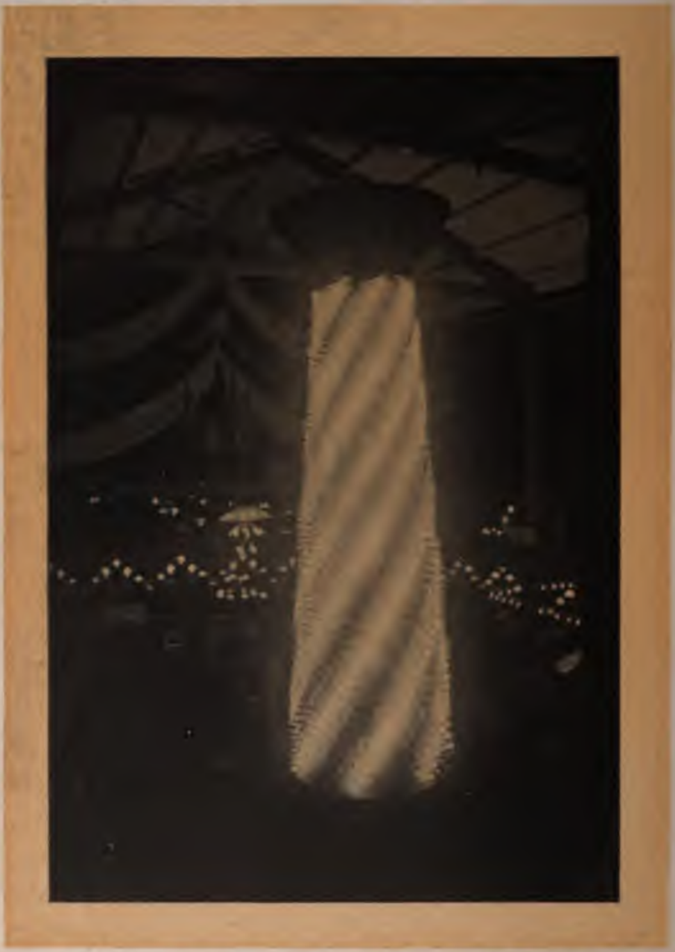
A good way to sell coal in warm weather. Striking and artistic. Through the courtesy of *The Edison Electric Illuminating Company of Brooklyn.*



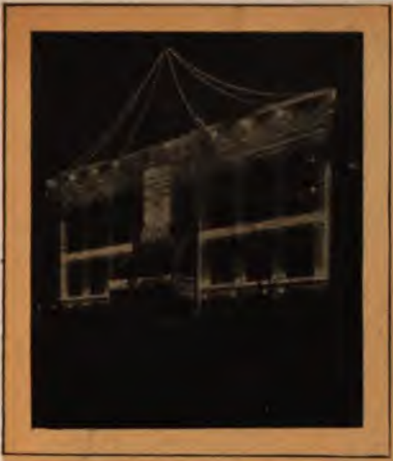
Emblems made with incandescent lamps. The possibilities in decorative and outline treatment of this order are almost infinite.



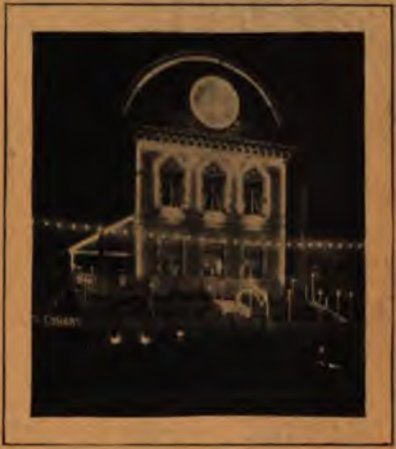
Brilliant vistas in Chicago at night. Through the courtesy of *The Chicago Edison Company.*



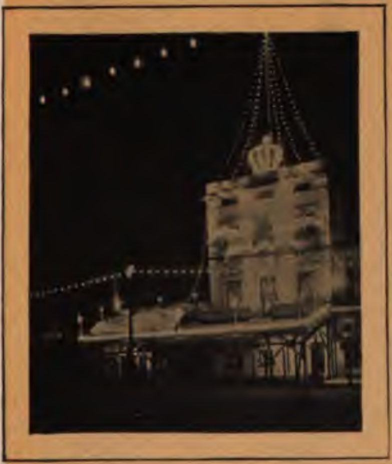
The first "Flashing Column of Light." Exhibited at the International Electrical Exhibition held by the Franklin Institute, at Philadelphia, in 1884. The spirals of Edison lamps, and a semi-circular sign with Edison's name in lamps on the base, were connected to a commutator turned by hand. Each hour the lights were flashed, the light running spirally around the column from bottom to top and oppositely, causing the column to appear to revolve. The Edison sign was flashed letter by letter and then altogether. Designed and built by and reproduced through the courtesy of William J. Hammer.



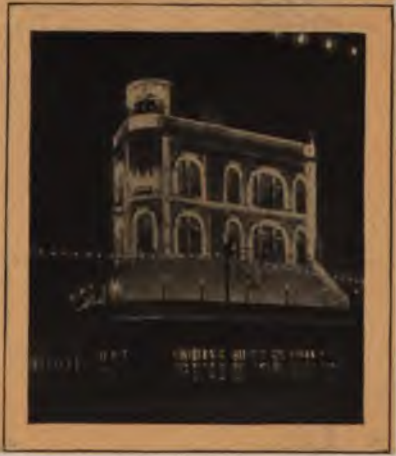
Harmony Club.



Pickwick Club.

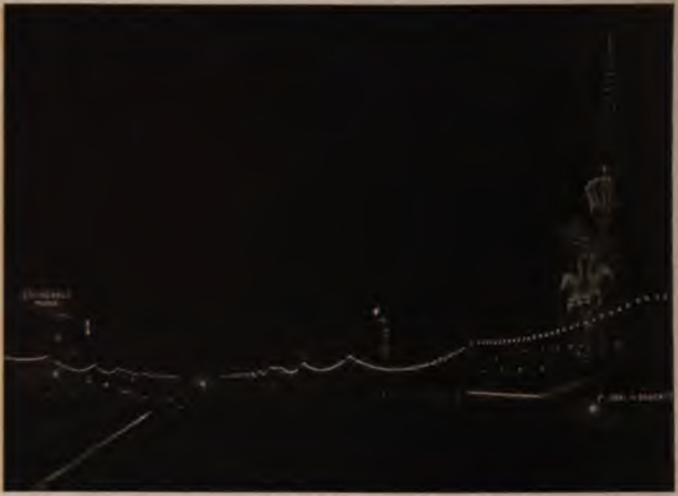


Boston Club.

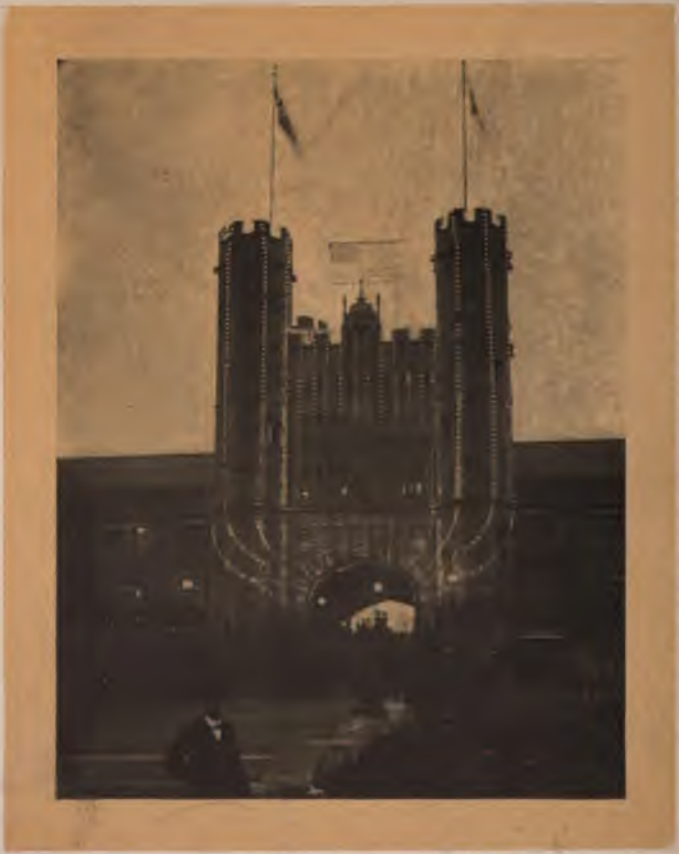


Chess, Checkers and Whist Club.

Special illuminations for the 1903 Mardi Gras at New Orleans, La. Through the courtesy of *The New Orleans Railways Company.* Copyright, 1903, by *John R. Teunisson.*]



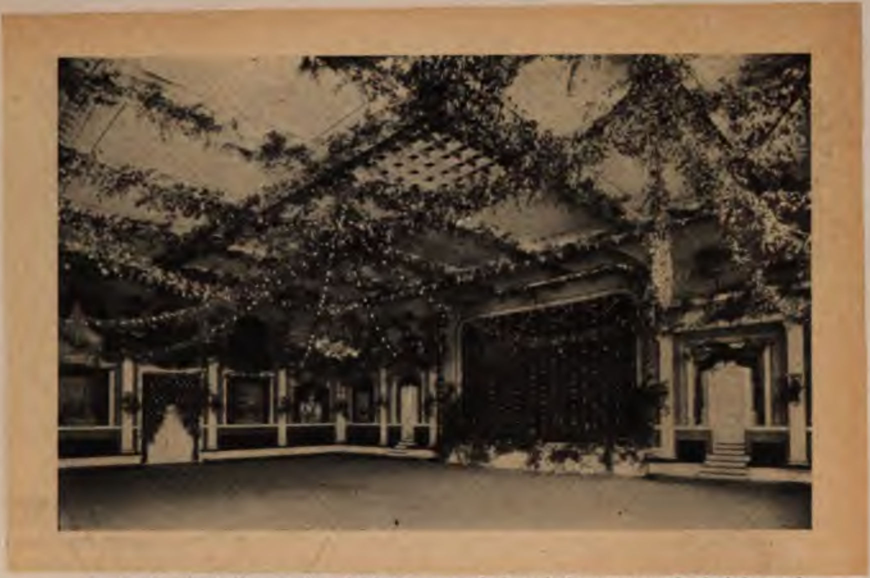
Canal Street, New Orleans, during the Mardi Gras. The streaks between the rows of incandescent lamps were caused by the passage of trolley cars. Through the courtesy of *The New Orleans Railways Company.* Copyrighted, 1903, by John R. Teunisson.



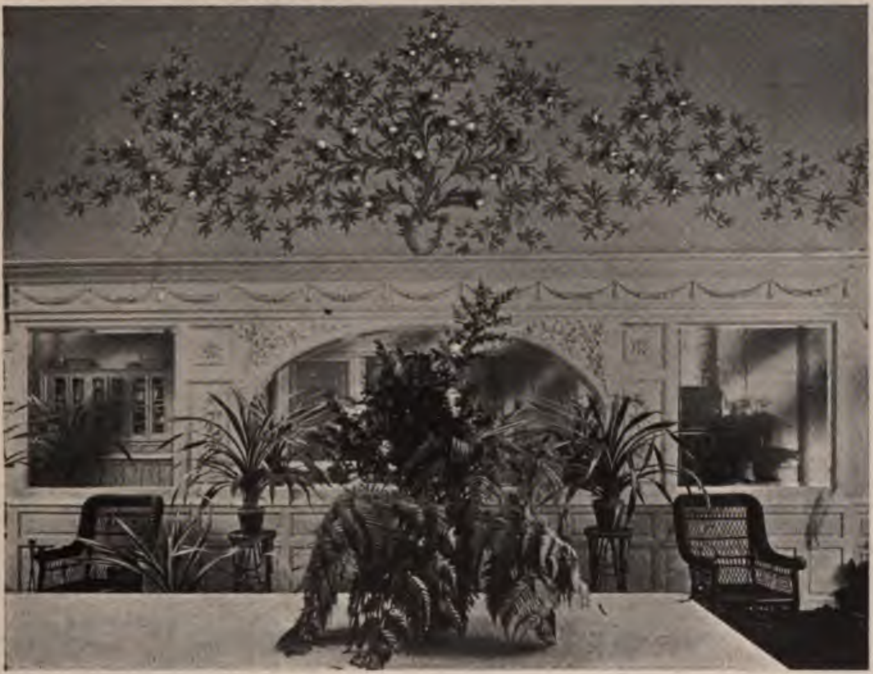
The Administration Building of the St. Louis Exposition as it appeared for the Dedication Ceremonies held on April 30, 1903.

The electrical decorations were made by the *Eblight Company, of America*, to whom we are indebted for this photograph—the first published.

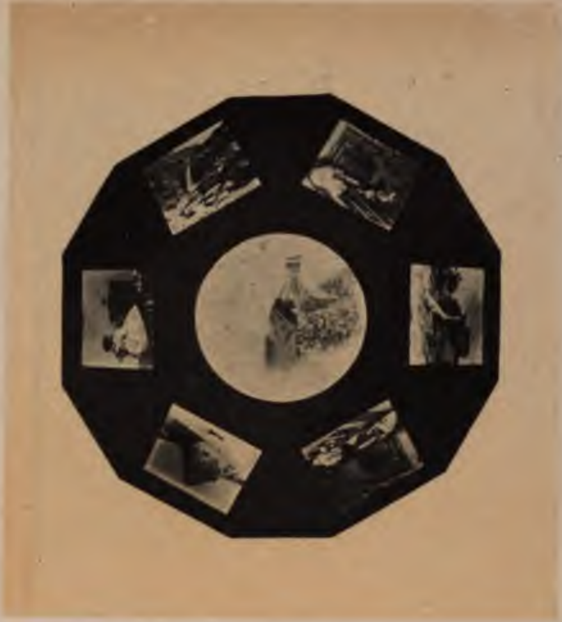
The lamps were in the Exposition colors—red, white, blue and yellow—and more than 10.000 were used for this occasion. The American flag, seen faintly between the towers, contains 300 lamps, also in colors.



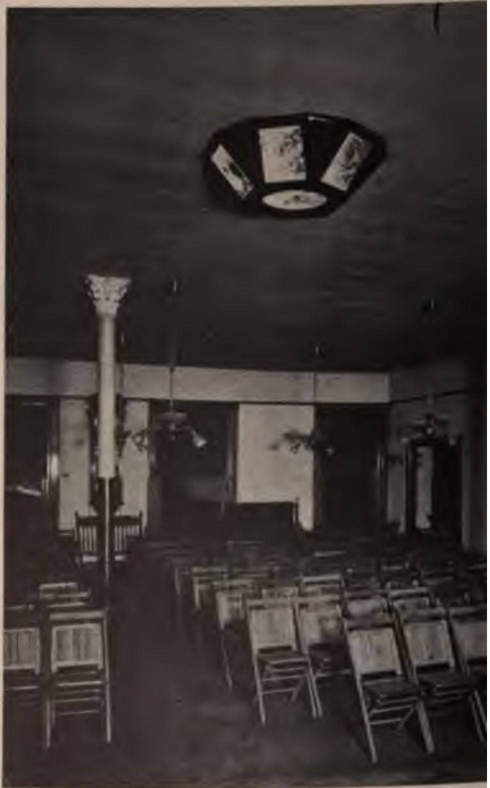
A St. Louis ballroom, in which the use of electric lamps greatly heightened the effect of the decorations. The Eblight System.

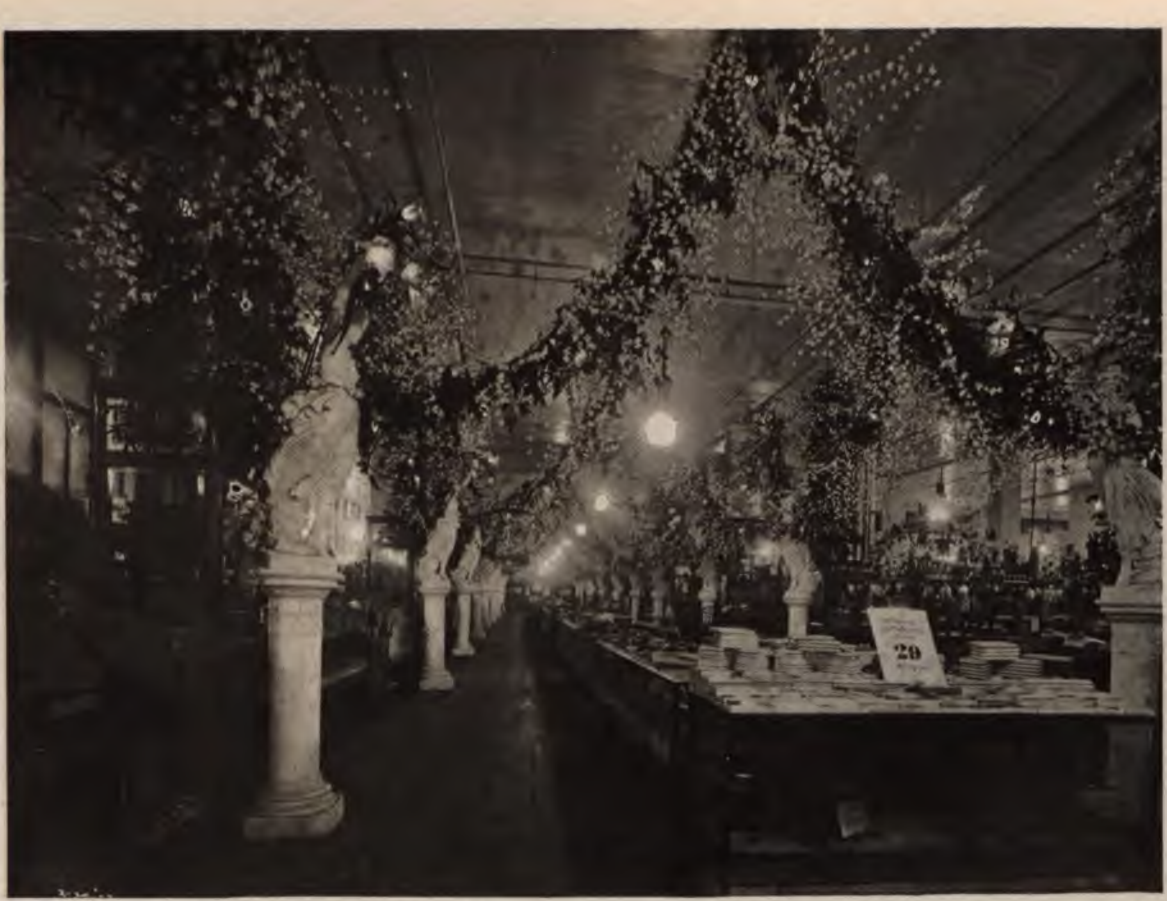


Mural decorations in the premises of a New York florist.



These views received from *The Denver Gas & Electric Company*, Denver, Colorado, illustrate a novel method of transparency illumination employed in Denver. The photographs are made on glass, framed preferably in black, and enclosed in a tight box within which are placed as many incandescent lamps (preferably of ground glass) as are necessary for effective illumination.

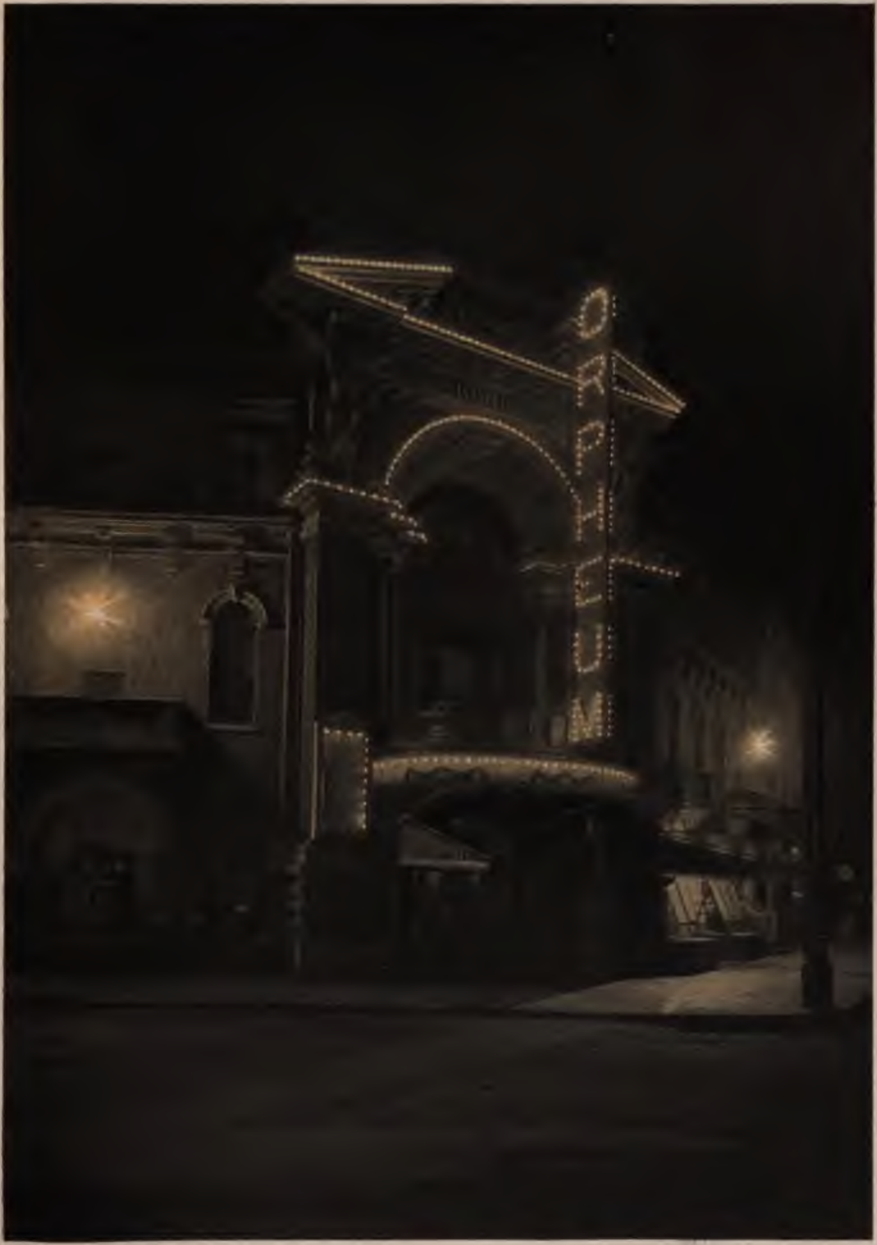




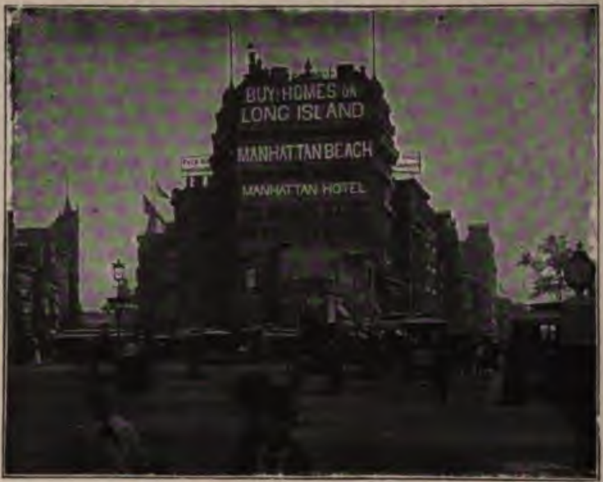
Decorations in a Chicago department store for the Easter holidays. Courtesy of *The Chicago Edison Company.*

Striking and effective illumination of the show windows of a Chicago department store. Through the courtesy of *The Chicago Edison Company.*

A corner in the large ballroom at Delmonico's. The electrical festooning was done by the Eblight Company. From the *Bulletin of The New York Edison Company.*

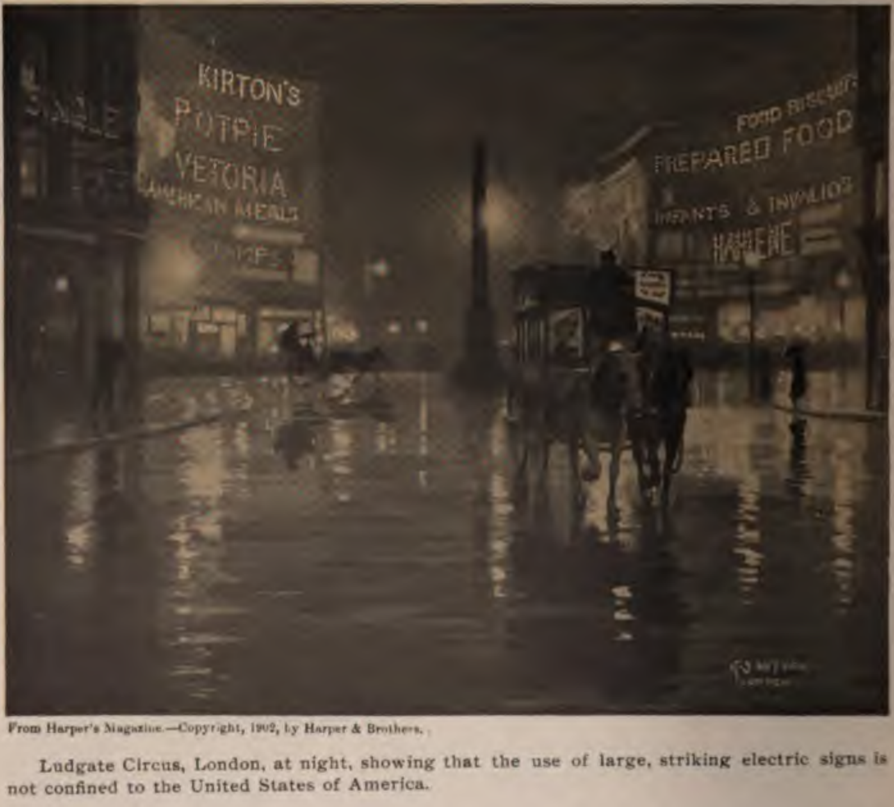


The Orpheum Theatre, Brooklyn, N. Y. This photograph, which was taken at night, is reproduced by the courtesy of *The Edison Electric Illuminating Company of Brooklyn.*



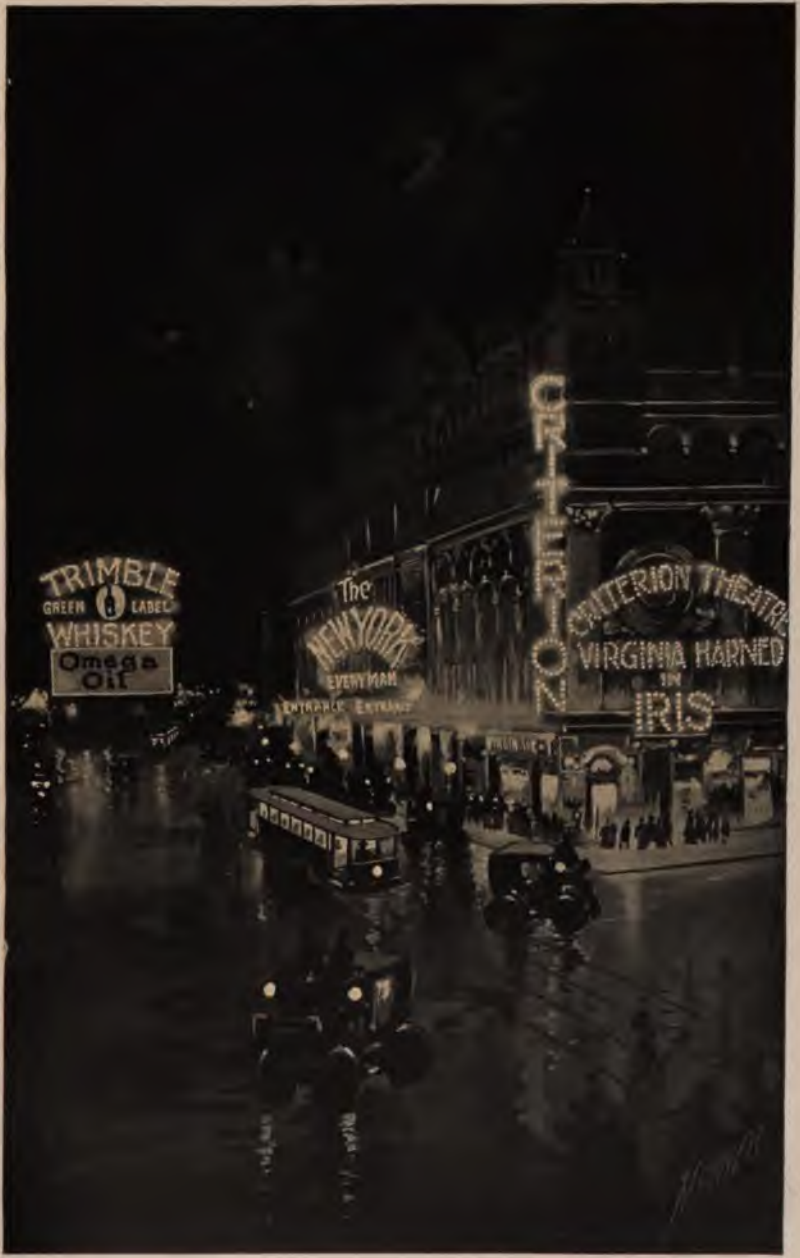
One of the largest signs erected in New York City. Parts only appeared simultaneously, the control being by knife switches, operated by hand.

Of historical interest as showing the buildings formerly occupying the site of the present "Flat Iron" Building. Courtesy of *The Electric Motor and Equipment Company.*



From Harper's Magazine.—Copyright, 1902, by Harper & Brothers.

Ludgate Circus, London, at night, showing that the use of large, striking electric signs is not confined to the United States of America.



Broadway at 44th Street, New York, at night. From the *Bulletin of the New York Edison Company.*

APPENDIX B

THE DEVELOPMENT OF ELECTRIC STATION POWER PLANT

BY ELIHU THOMPSON

Twenty-five years ago the electric station had its beginning. In 1878 a number of dynamos of the alternating type were belted to steam engines and used for lighting the Place de l'Opera and Rue de l'Opera in Paris. The practice of belt driving, in which the dynamo speed is much higher than the engine speed, was well-nigh universal for a period of 10 to 15 years thereafter. The earliest machines, which were direct-connected to the engine without belting, were probably the Edison Jumbo dynamo and the Gordon alternator, both of which were brought out in 1883. The machines up to that time were of very limited capacity. A dynamo that would use 25 to 50 horse-power to drive it was one of large output.

The movement toward direct connections was simultaneous with a great increase of capacity over the then existing machines. The Edison Jumbo was a direct-current, constant-potential dynamo of about 1,200 16-cp incandescent capacity, or about 100 kilowatts in output; small enough, it is true, as compared with our present standards. The Gordon alternator was a revolving-field machine, the field being about eight feet in diameter, revolved by the engine direct (and forming a flywheel for the same) at a speed of from 140 to 180 revolutions per minute, the periodicity being about 45 cycles. Its capacity was about 5,000 incandescent lights, or, roughly, 350 kilowatts output. These were very large machines in their day. The Edison Jumbo weighed 25 tons and the Gordon alternator 22 tons. It is interesting to note that the Armington and Sims engine that drove the Edison Jumbo was specially designed to secure relatively high speed, so as to meet, as far as possible, the dynamo conditions. Later on, these same high-speed engines were extensively employed in electric stations, belted to dynamos running from 600 to 1,500 revolutions per minute, and employed for incandescent or arc lighting in small units. The example of direct connection gradually spread, and the direct-connected electric plant has at last almost entirely displaced belt-driven machines.

The growth was rather slow, and less rapid in the United States than in Europe. There was, of course, much work to be done in perfecting details, and the substitution of the large direct-connected unit for belt-driven types may have been retarded by the exceedingly rapid development in various electrical fields. The replacement came about partly on account of the increasing output, not only of the stations but of the units themselves—up to 5,000 or 6,000 kilowatts each in some of the large generating stations to-day. As the size of the unit increased, the speed, of necessity, came down to accommodate the heavy reciprocating steam engines employed. This, however, so far as the dynamo was concerned, was only to be accomplished by the use of very massive machines. The dynamo machine and other electric machines are essentially high-speed machines, and any straining for low speed must always be paid for in excess of material or diminished efficiency, or both. Nevertheless, the direct-connected, slow-speed machine of sufficiently large capacity has proven itself very satisfactory in practice, and has become almost universal.

Still, engineers have not been content, and it seems as if we were on the eve of another decided change. In some cases in cities the vibrations caused by reciprocating engines have in fact forced a change in the character of the motive-power machines. Instead of bringing down the dynamo to steam-engine conditions, we now bring the steam engine to dynamo conditions by changing the type of engine employed. In fact, the new problem was to bring down the turbine engine, with the excessive speed required for economy of steam, to such speeds as were within the range of feasible dynamo construction. It is now about 12 to 15 years since the Parsons turbine was applied to drive direct-connected dynamos of small capacity. The earliest of these ran at about 10,000 turns per minute, and really presented the difficulty that the speed was far in excess of reasonable dynamo speeds. The thing had, in fact, been overdone. Growth in size of units and perfection of design allowed the speeds to be lowered to about 3,000 turns in moderately sized units, and still lower in the largest units, thus adapting the speed to a proper proportioning of dynamos. The lower limit of speed depends on the size or capacity of the turbine engine, but it will probably not go much below 500 turns per minute, even in the largest units.

In the DeLaval turbine, the construction is such that reasonable speeds for dynamo work are only to be obtained by a remarkable development of reducing gear. In such a case the plant becomes no longer direct-connected. While in the Parsons form of turbine the steam entering at one end over the whole wheel and passing in succession sets of vanes carried thereby and stationary vanes or guides alternating therewith, progressively expands until it reaches the exhaust end ; in the DeLaval the expansion takes place in a nozzle or set of nozzles directed against the vanes of a portion of the periphery of the vane-carrying disc. The form of jet or nozzle is flaring toward the wheel, and the conversion of the kinetic energy of the steam into motion in one direction takes place in the expanding nozzle itself and the fall of temperature and pressure therefore occurs largely before the steam reaches the wheel, which itself revolves in a fairly good vacuum provided by the condenser. In the lately developed form of turbine, due to Mr. Curtis, the work of the steam is divided into distinct stages, part of the expansion taking place definitely in each stage, and part only of the periphery of the wheels being acted on by the jets or by steam passing the intermediate guides. The action of compounding is somewhat analogous to that in a compound engine in which the turbine wheels of the successive stages are taken to represent the succession from the high pressure to the lowest pressure cylinders.

The turbine engine is essentially a machine whose efficiency depends in large measure upon its exhausting into a vacuum. The condenser is therefore a very important auxiliary.

In the Curtis turbine, the ability to secure relatively low speeds is shared with the Parsons form, and the ability to govern output by increase or decrease of steam entering the nozzles is shared with the DeLaval form. This latter feature is valuable in governing and in meeting overload conditions. The present intention, however, is not to go into the details of turbine construction. It is rather to point out and emphasize the apparent fact that the low-speed, direct-connected unit—the huge generating plant of to-day—must probably eventually yield to the much smaller relatively high-speed, and less costly, turbine-driven plant. While, perhaps, there will be little if any gain in steam economy at full load, the turbine has the decided advantage that the efficiency curve holds up for partial loads, even far below half-load, particularly when the governing is accomplished as above indicated. This valuable feature is, as is well known, entirely absent in the compound engine of ordinary type, the efficiency curve falling off very rapidly with decrease of load to a point which soon neutralizes all the advantage of compounding. The turbine is essentially a high-speed rotary engine, an ideal for electric machinery, with simple bearings, constant angular velocity, high light-load efficiency and light weight. It is particularly adapted to the large units now in use so extensively. The turbine seems destined to play a large part in the future development of the electric power and lighting station. While it does not promise great gain in steam economy under full load, as compared with the reciprocating types, the average result where load changes are taking place will doubtless be that a much better economy is obtained. The gains in original outlay in space taken up and in maintenance costs seem to be so considerable as to be decisive as to its adoption.

Looking still further ahead, can we be assured that it is the ultimate step? Laying aside, as improbable, the direct conversion of the energy of fuel into electric energy, inasmuch as we see no promising signs of its possibility, and considering the fact that the cost of fuel will probably advance steadily as our near-the-surface coal supplies are worked out, it would seem that we must perforce at last turn to those forms of prime movers that have inherent possibilities of developing much higher efficiencies in the use of fuel than are existent in the steam engine. Even at the present day in certain relatively very small units, the internal-combustion engine, such as the gas or oil engine, has shown efficiencies nearly double that of the best steam-engine plant and the partial-load efficiency is also satisfactory. There can also be no question that the internal combustion engine is susceptible of improvement, such that in large units the present attained efficiency will be far surpassed. It seems even probable that an efficiency of heat conversion up to between 40 and 50 per cent will some day be practicable, a result about three times better than is attained with steam. The engines that would be used would naturally be of large reciprocating type and comparatively slow speed, unless some form of gas turbine be developed, a matter upon which serious doubts may be expressed.

What is meant by a gas turbine, is a turbine driven by gas expanding from a chamber in which the gas is burned at high pressure and temperature with the requisite amount of air. Such a machine demands the pumping of the air and gas prior to their combustion. The waste gases are, of course, incapable of condensation in a condenser. The problems involved in a gas turbine are, then, altogether different from those of a steam-turbine engine, and they are necessarily more difficult of solution. In favor of the ordinary gas engine is the fact that all grades of fuel gas may be used with almost equal facility, and even the poor gas, of very low calorific value, such as is sometimes a waste product of blast furnaces in iron smelting, may be used. Coal dust, culm, and waste of mines of low fuel value may be made to yield gas suitable for feeding gas engines. Liquid fuel, as oil of various grades, is also available, and engines have been run, experimentally at least, by feeding them simply with coal dust itself. The richest fuel, down to the lowest and poorest grade, may therefore be employed directly or indirectly in gas-engine work, and a good efficiency, much exceeding that obtainable with any form of steam engine, is even now obtainable, although the units are not very large. Much remains to be done, however, to render the larger types of gas engines equally available with steam engines, and the day of their rapid introduction is probably still far enough away to cause little need for hesitancy in the adoption of turbine plants for electric stations.

Where soft coal is first converted into gas by a gas producer, useful by-products may be obtained, which have sufficient value to warrant their being collected and sold. Moreover, the gas may be continuously produced and stored until needed. These conditions are, of course, well known. An advantage obtained from the gas engine, and one that has been frequently pointed out, is the short time required to get it into work and the equally quick shutting down of running expense when it is stopped. Provided only the store of fuel is ready to be drawn upon, there is no expense for fuel except during running; neglecting, of course, interest on plant. A quickly stopped and started gas-engine plant can take care of load peaks most effectively and efficiently. But if the gas engine should ever become a general source of power, what becomes of our driving? Will it be brought again to belting or some form of gearing up for increase of speed, or will the heavy direct-driven dynamo again be found coupled to gas engines instead of reciprocating steam engines?

It is not probable that large gas engines will be run much faster than steam engines of equal power, so that the queries just propounded will need to be answered by future engineering, provided we are right in assuming that the future economical conversion of the energy of fuel into power must come through improvement and increase of size of gas engines.

In the considerations above advanced, the use of water-power is purposely neglected. The amount of water-power that can be rendered available with economy is limited, and it is fairly local in spite of long-distance transmission, while the need of electric generating stations will be more extended and universal as time goes on. The heavily trafficked trunk-line railroads will need them, and the replacement of small powers by electric motors is a future business, which has only just begun, according to all present indications.

APPENDIX C

A NEW FORM OF PHOTOMETER

BY RALPH R. LAWRENCE

The removal of the department of electrical engineering of the Massachusetts Institute of Technology to its new quarters in the Lowell Building necessitated, among other things, the construction of new photometric rooms for arc and incandescent lights. In the design of the arc-light photometer the aim was to provide an apparatus by means of which any photometric or electrical measurements could be made with ease and accuracy on arcs, or other lamps of high candle-power, which of necessity must be burned in an upright position. The arrangement finally adopted was to keep the centre of the arc, the centre of the photometric screen, and the centre of the standard, always in the same straight line, and by swinging these about a horizonal axis directly under a photometric screen, the arc always remaining in a vertical position, obtain the intensity of the lamp to be tested in a vertical plane at any angle between plus or minus 90 degrees with the horizontal. There is nothing new in this arrangement, but it is believed that the photometer differs enough in actual construction from existing forms to warrant a description. The chief objection to be met was the mechanical difficulty of providing ample space between supports in which any arc or other lamp, with its attached shade or reflector, might swing, and at the same time keep the distance of the photometric screen from the observer's eye within moderate limits. The distance between the arc and the photometric screen was fixed at ten feet and adjustment for equal illumination was made by varying the position of the standard.

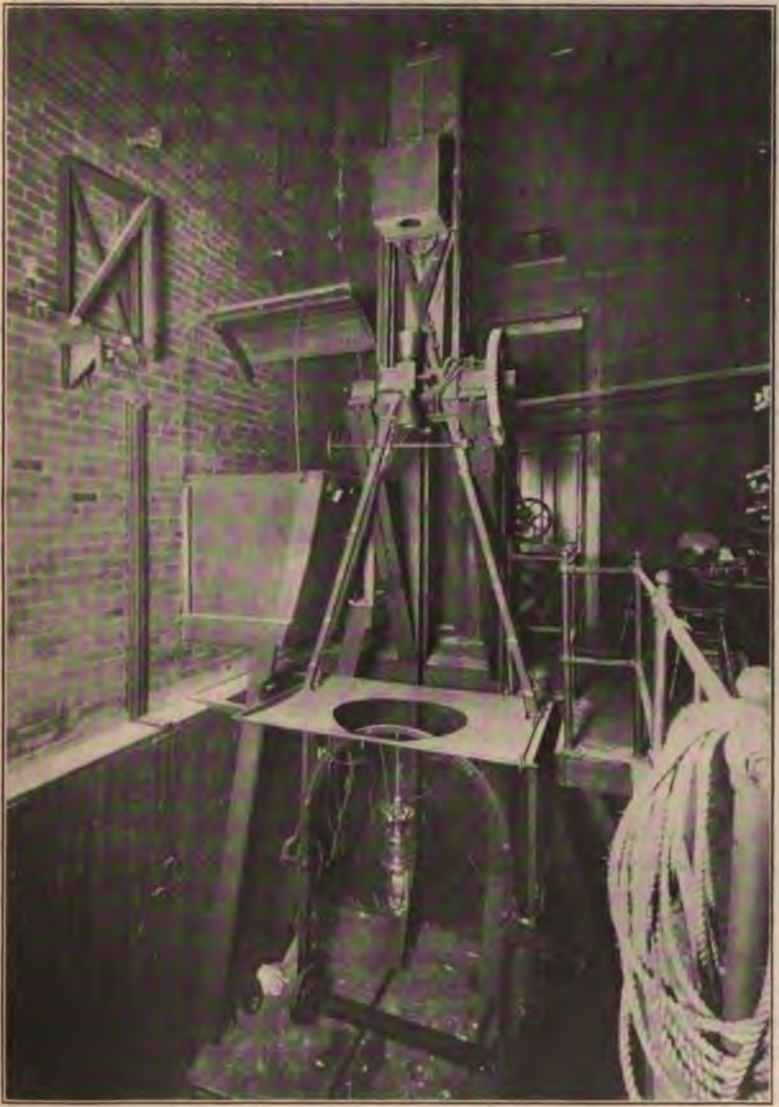
Although, when comparing lights of different colors, considrotated. These two steel shafts are made slightly spherical on the ends and rest in roller bearings carried by castings bolted to the main frame at a distance of 10 feet from its shaft. The U-shaped frame carries the lamp hung from its top, as shown in Figure 2, while counter-weights bolted to its extremities serve to keep the whole in an upright position. The lamp is adjusted so that its centre is in line with the centre of the shafts about which the U swings. The centres of these shafts are placed seven inches above the top of the channels, and since the axis of the photometer must pass through a line joining these, the position of the photometric axis is thereby fixed at seven inches above the main frame.

Four rails, made by shearing down steel angles to one inch on a side, are fastened to the narrow part of the main frame, one directly above and one directly below each side channel. The two upper rails serve as guides for a light carriage, while a similar carriage is placed beneath. Both carriages are attached to a chain that passes over small spur-gears in such a way that when the top carriage is in one extreme position the lower one is in the other. Each has a movement of about six feet, which is controlled by a 10-inch hand-wheel just in front of the axis about which the main frame swings and within convenient reach of the operator. The forward shaft, over which the chain passes, is geared to the hand-wheel in such a way that a quarter of a revolution corresponds to a linear displacement of the carriages of about five inches.

A tin box placed upon the upper carriage contains sockets for three secondary incandescent-lamp standards. These sockets are fastened to a 135-degree sector of an aluminum disc, so pivoted to the bottom of the box that any one of the lamp sockets may easily be swung into a central position. The sockets are provided with horizontal and vertical adjustments for centring the lamps. Counter-weights are placed on the lower carriage to balance the system.

To avoid any error that might result from reflection from the back of the box, the lamps are calibrated in position. The inside of the box is thoroughly blackened.

The photometric screen is placed directly over the axis of the main frame, and the position of the lamps relative to this is read off on a Chesterman tape, one end of which is fastened to the tin box. This tape also gives readings directly in ratios. As the box is moved in adjusting for equality of illumination on the screen, the tape winds or unwinds on a small drum below, but slightly in front of, the photometric screen. A spring



attached to the drum keeps the tape under uniform tension and prevents sagging.

The reference point or index for the scale is directly beneath the screen, and is always in front of the observer, whatever may be the position of the main frame.

The adjustment of the photometer is made from a small balcony built about one of the side columns that support the photometer, while the electrical measurements are made at a table in another part of the room. All wires for current or potential leave the photometer frame over its axis and go directly to this table, where the various potential leads may be connected by means of switches to the voltmeter.

The potentials at the arc, and the standards, are regulated by variable carbon resistances inserted in the current mains for the lamps. A loop is provided for an ammeter in the circuit of the arc lamp.

The current leads for the arc and the standards are brought out to switches that may be connected to any of the various laboratory circuits. The standard lamps are generally connected to a special constant-potential source which supplies only photometric standards.

The photograph reproduced on page 5 gives a good idea of the general arrangement of the apparatus.

APPENDIX D

QUESTION BOX

INTRODUCTION

In preparing the Question Box, which I have the honor of presenting, it was soon apparent that it was certain to overrun the modest limits I had anticipated, and some method of abridgment was imperatively necessary. It was therefore decided to omit such questions as would require personal investigation to enable one to make an intelligent answer, as well as such as are largely matters of opinion, and never will be settled conclusively.

Many answers covering practically the same ground were received, and in such case preference was given to the earliest, the most clearly expressed and the most comprehensive, while "yes" or "no" answers were omitted in favor of those giving reasons for the opinions advanced.

In deference to the time-honored custom of the association, all mention of names of manufacturers, brands, trade-marks, etc., has been omitted wherever it was practicable to do so. In some cases, however, a strict application of this rule would have resulted in rendering otherwise valuable contributions entirely meaningless, and some latitude in this respect has therefore been considered necessary.

I trust that, in view of these explanations, no offence will be taken or disappointment occasioned by such omissions and changes as have been made, although it has resulted in the loss of some excellent material which might profitably be brought up in executive session, where every member is privileged to speak his mind freely, without let or hindrance.

The Question Box should be one of the most valuable features of the convention, but only co-operation from all members can make it so. Most station managers and superintendents can ill afford the time required to prepare an elaborate paper for the convention, but there are few indeed who can not spare a few minutes to dictate an answer to a question which they have met and solved in every-day practice.

But the great advantage of the Question Box is the selective feature. Interesting as are the papers read at the convention, it frequently happens that one's own particular problem is not touched upon at all. We can not all choose exactly what we should most like to hear at the convention, but we can and should send in such questions as will bring out just the information we need.

While much valuable data on subjects of interest may always be obtained from acquaintances made at conventions, it may easily happen that one fails to meet the very man who could best fill his wants. The Question Box takes you to him without effort, without delay, and without unduly encroaching on his time.

It will greatly enlarge the scope and value of the Question Box if each member will jot down, from time to time, such knotty problems as he encounters, sending them to the association headquarters at once, where they will be carefully filed for use at the next convention.

One of the first circulars prepared this year requested answers from all members to the following questions:

1. What is your method of mapping pole lines, indicating the size of wire, distinguishing mains from feeders, incandescent from arc lines, etc.?

2. How do you keep track of the location and sizes of your various transformers, meters, etc., and the maximum active load on the same?

3. What precautions do you use in distributing free lamp renewals, to prevent consumers from selling or giving lamps to dealers, isolated plants or other central stations?

Although many replies of special interest and value were received, it will be impossible to undertake more than an outline of the various methods described.

Mapping of Lines

Many of the smaller stations find no necessity for a map of any kind, as the number of wires and extent of the lines are so limited as to be easily remembered, but among the larger stations there are four distinct plans in use.

1. A general map, in which all circuits are indicated by colored lines or symbols. This plan is subject to the serious objection that changes are difficult to make, and that, if defaced or blotted, the entire map is ruined.

2. A general map, in which circuits are indicated by colored threads strung on pins.

Both of these plans have the disadvantage that the maps are cumbrous, complicated, and not easily duplicated. Where there is a large number of circuits it is difficult, if not impossible, to distinguish them apart, much less to include all of the information that an arrangement of this kind might, and should, show.

3. A card index with a diagram of each pole where a change occurs is an excellent plan, and it gives a good opportunity to show sizes of wires, the relative position of different phases or polarities, arrangement and location of fuse boxes, lightning arresters, transformers, etc., while changes are easily and quickly made and readily verified. Running over such an index is precisely like following out the pole line. It enables the superintendent to give much more accurate and detailed instructions in case of necessity than would otherwise be possible; a point of vital importance in cases where your old lineman who "knew it all" has just left you without notice, and it is necessary to give such instructions to his successor. Such a card index should preferably be supplemented by a general map showing simply the location of pole line with general location of lightning arresters, transformers and street arc lamps.

4. A general map, drawn to large scale, showing location of pole line, and such general information as can be conveniently included, supplemented by small skeleton maps drawn to a scale of about 1,000 feet to the inch, a single line representing a street. There is one such map for each arc, alternating or direct-current power circuit, showing all lines and all such details as location of arc lamps, transformers, fuse boxes, lightning arresters, etc. These maps are made on tracing-cloth, from which blue prints may be made for the use of foremen inspectors, troublemen, etc.

Meters and Transformers

In many small stations no record is kept. It would seem that this is a careless course to pursue in view of the amount of money invested.

The two systems in general use for such records are as follows:

Book

The sole advantage of this plan seems to be that individual records can not be lost or mislaid. The great disadvantages are that no symmetrical arrangement is possible, as any classification adopted will soon be outgrown; that any material rearrangement means rewriting the entire book; that only one person can work on the record at any one time; and that the space for data as to removals, replacements and general history, will be too limited in some cases and unnecessarily great in others.

Card Index

This is by far the most flexible and convenient arrangement. Any desired classification or change in classification can be made with ease, and I believe this system should be universally adopted.

The plan of renumbering each meter and transformer as received is an excellent one, particularly where the new number indicates the size as well as the serial relation, and cards of different colors are used to indicate the various makes and types of transformers or meters. It is an advantage to have a separate series of numbers for each size. For example, if the number is divided by a hyphen, the first part indicating the capacity and the rest the serial number, we should have ½-1, ½-2, ½-3, etc., for 500-watt transformers; 1-1, 1-2, 1-3, etc., for 1-kw transformers, the highest number in any series indicating the total number of that particular size. There should be separate compartments for transformers or meters "in use," "in stock," and "undergoing repairs," the card being shifted from one compartment to another as desired. The new number should be stencilled in a conspicuous place on the case of each transformer or meter as received, and all the descriptive data entered upon the card, which should be put into the "in stock" compartment.

When installed, all the data regarding location, customer, etc., should be entered on the card, which should then be placed in the "in use" compartment.

The following list shows all of the information called for in the various sample cards submitted. There will, of course, be more or less difference of opinion as to the necessity for some of the headings and the desirability of any one particular combination, and consequently no individual cards are illustrated. Several manufacturers publish meter and transformer cards containing more or less of the headings given below.

Meter Cards

Company's number
Make
Maker's number
Type
Form
Constant
Frequency
Amperes
Volts
Phases
Two or three wire
Date received

On the back of card there should be columns headed, respectively, "Customer," "Address," "Installed," "Removed," and "Cause."

Transformer Cards

Company's number
Make
Maker's number
Type
Frequency
Capacity
Volts, primary
Volts, secondary
Date received
Date installed
Location
Previous location
Date removed
Cause
Circuit
Phase

Data as to secondary main or network may be added if desired. These cards should be supplemented by a consumer's record card, filed alphabetically, which should show location and number of meter, the number of transformer feeding the installation, and the connected load; ample space being left for change in the latter, and for such other data as may be deemed necessary.

There appears to be no systematic plan in use for keeping track of the maximum active load on meters and transformers. This is a matter of much importance, and I think that wherever there is any possibility of overload, all such apparatus should be tested during the season of heavy load, and a careful record kept.

Lamp Renewals

Most stations require the customers to give a burned-out lamp in return for every free renewal, and take care to dispose of the old bulbs promptly in order to prevent their repeated use. This is only a partial protection against fraud, as burned-out lamps of any make are easily and cheaply obtained. This plan is therefore supplemented by the following expedients, either singly or in combination.

1. Provide each customer with a card showing his original installation, and enter upon it the dates of renewals and the number of lamps renewed on each occasion. This makes it impossible for any one but a consumer to obtain lamps fraudulently except by connivance with some consumer.

2. Compare the number of lamp renewals with the meter readings. This is one of the best possible checks. Some companies give a free renewal for a certain consumption of current whether the consumer requests it or not.

3. Paste labels on the lamps, and date them or number them serially. The former plan seems to be of little or no real advantage, while the latter would be too cumbersome for a large station, as it involves comparing the number on each bulb returned with the office record showing the name of the consumer who received it originally.

4. Paste a label giving the name of the company on each lamp renewed. This requires a good deal of labor, and can not prevent fraud, as the label can be easily imitated.

5. Stamp the name of the company on the insulation on lamp base. This is impractical in the case of some types of lamps, as the insulation used is black.

6. Have the name of the company etched on the bulb. This is probably the best plan, but, if used, must be limited to lamps supplied to consumers. This is a serious disadvantage

where many lamps are sold to isolated plants, as it involves keeping a separate stock of unetched bulbs.

In conclusion, I beg to thank the various members who have taken the time and trouble to prepare questions or answers, or who have suggested the names of others whom they deemed especially qualified to answer certain questions.

Many valuable suggestions were received from Mr. Henry L. Doherty, who kindly permitted the use of some of the forms he had prepared for a similar Question Box, and I am greatly indebted to Miss Harriet Billings, assistant secretary of the association, for the interest she has displayed and for the effective assistance she has so cheerfully given from the first.

H. T. HARTMAN, Editor.

QUESTION BOX OF THE TWENTY-SIXTH CONVENTION OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION

No. 1.—Have any users of water-power found a remedy for slush or anchor ice in their screens and wheels?

The only remedy I know of is to remove racks or screens and allow the water to flow through the wheels unobstructed. If the wheels are turning under a fair load, the anchor ice, or frazil, will usually go through all right. This is a dangerous thing to allow, as sticks, clubs, etc., will also go into wheels. Sometimes a rearrangement of forebay, canal, dam, etc., might change conditions so that anchor ice would not be troublesome, but where it is troublesome I know of no method of handling it successfully. GEORGE B. LAUDER.

The anchor ice on rack screens or water wheels may be prevented by arranging the ponds and inlets to wheel houses so that said ponds will readily freeze over. If the river from which power is taken is sluggish enough to allow freezing early, and if the inlets are made so wide and deep that the pond will freeze over at the same time that the river does, there will be no trouble from anchor ice after it is frozen. In 15 years' experience with a water-power having a capacity of 1000 horse-power, we have never had any trouble from anchor ice, except once in a while—perhaps once in four or five years—when there has been a strong wind during the night when the river was freezing over. At such times there may be trouble for twenty-four hours or so, according to conditions. In the northern latitudes, and where the river does not come over swift rapids in proximity to the power-house, there should be no trouble from anchor ice after the river is once frozen over.

EDWARD PETERSON.

This is a difficult question to answer. Our experience has been that, while there is no absolute freedom to be had from anchor ice, there are various methods of securing partial relief from this trouble. We think that if we can cause surface ice to form in the pond above our flume, even if but a couple of hundred feet wide, anchor ice running will be so softened that it will not stick to the wheel runners or cause trouble by plugging up the buckets on the wheel. This we accomplish by placing numerous booms, and then making a kind of grill by connecting them with old poles. The result is that one cold night is sufficient to cover the space with surface ice, where if left open it would not freeze in a week or ten days.

Again with ordinary vertical wheels, such as Leffel, Trump, and others of the same pattern, a very useful arrangement is to tap a hole in the top of the wheel case and connect a three-quarters or one-inch steam pipe so that steam may be admitted to the inside or back of the runner, and by closing the wheel-gates and blowing steam inside of the wheel for a couple of minutes, all ice in the buckets will be so softened that it will drop out at once when water is admitted to the wheel. This steam pipe can be protected by placing a piece of two-inch or two-and-a-quarter-inch pipe around it and packing full of plaster of paris and sawdust to prevent condensation. Slush ice and fine snow on the surface of the water seldom trouble us, and when it is running it can usually be diverted by sheer booms placed above the in-take of the flumes.

W. J. TROTT.

In my experience with water-power I have been unable to find a remedy for anchor ice on screens or racks above wheels. At our plant, during the time when anchor ice is running, we keep a force of men on the racks with rakes. We do not attempt to rake out all of the ice, but to make numerous openings. The water rushes through these openings with great velocity and very quickly enlarges them, until finally the rack is clear. The above is not a remedy, but a means of quickly getting rid of the annoyance. I would say, further, that we use a rack made of steel plates a quarter of an inch thick by two and a half inches wide, set on edge, the openings between adjacent strips being two and one-half inches. We find great advantage from the use of a steel screen instead of a wooden one, the ice wearing away much more rapidly over the former than it does over the latter.

M. A. BEAL.

Anchor ice is supposed to be formed in riffles in a river, and I think best results toward preventing anchor ice have been accomplished by drowning out the riffles by raising a dam or cutting new channels, so that water can find its way down stream without great agitation. H. R. WEBER.

The handling of anchor ice is a subject requiring years of experience and much study. The reason a long experience is a necessity, lies in the fact that anchor ice seldom runs twice alike. A study of the physical conditions causing it is absolutely necessary, as an ounce of prevention is worth much cure. A well-known physical phenomenon is that of the possibility of cooling water to a point many degrees below the actual freezing point without congelation taking place. The experiment may be of interest, and may be performed by dropping ether upon a thin glass tube filled with water in which a thermometer has been previously placed. By this means a temperature some six or eight degrees below the freezing point may be obtained, provided the tube of water is held perfectly still by a mechanical holder. If upon attaining a temperature below freezing the tube be struck with a lead-pencil or be shaken a little, immediate congelation will occur.

This experiment is merely a repetition of the process that we observe in nature. We have a very cold day. The water in the river—or in the ocean, for that matter—is cooled to below freezing, and the agitation, being ever present, causes the formation of ice; but, owing to the great body of water and the movement therein, it does not freeze solid at once, but is kept churned up, making vast quantities of anchor ice. To the average man, knowing nothing of such phenomena, the power for evil of this anchor ice is a marvel upon first acquaintance. Under the microscope the anchor ice takes the form of tiny, flat and extremely thin plates. The lodging against the water racks of these masses of little plates will shut out the water as well as a cork stopper would. The writer has stood inside of racks that were covered with anchor ice where there was a head of 14 feet of water outside, without wetting his feet while wearing low rubber boots. From this it will be seen that it is of vital importance to prevent the accumulation upon the racks and to remove the cause at the earliest possible moment. Under high heads the removal of the racks and forcing the anchor ice through the wheels, as has been done at Niagara, has, I believe, proved effective. But under low heads, say 20 feet or under, the masses of ice will even plug the turbines.

Our plant is located upon the Penobscot river, which is noted as an anchor-ice maker, being broken up into short sections by numerous rapids. Such rapids furnish all the agitation needed to form anchor ice. But the water is too strong to permit of any work being done here, so we must do our work in the dead waters. Log booms, large ropes, etc., are stretched in the water, and, beginning at the shore, behind some projecting point, the floating masses of anchor ice are towed to the shore ends of these booms and frozen to the shore and boom. This process is continued, gradually building out from each shore, until a bridge is formed across the river. This bridge, or rather boom, of ice then accumulates the floating anchor ice and it builds back until the whole river is covered. The writer has seen two miles of this building-back take place in half a day in a river from 300 to 600 feet in width. Experiments have been made by stretching cheese-cloth sheets over the surface of the water, which, freezing rapidly, starts the real ice in forming.

In absolutely still water anchor ice forms only in small quantities, under the influence of heavy winds to furnish the agitation. The writer observed an example of this at Cape Cod last winter, where the shore was piled five feet deep with anchor ice after a heavy storm. Another fact, known to the student, but to few practical men, is that the water gains its greatest density a short distance under the ice and remains at plus four degrees centigrade. It will at once be seen that no anchor ice can form at this temperature, so once the river is sealed by a sheet of ice, the trying days of anchor-ice troubles are over. Reasoning along nature's lines, we have furnished this coating in advance of the freeze, by covering the forebay over with a tightly built wooden cover. Those of you who have this matter at heart have no doubt noticed that at the rapids, where the rivers never freeze, a continuous stream of water vapor arises, for the reason that the temperature of the water running out from under the ice sheets is comparatively high. This vapor we find arises in like manner out of our forebay cover when the traps are opened, and we have found it quite an efficacious means of preventing the anchor ice from freezing to the water racks.

Our power transmission, though short, is one of the first instances of moving a waterfall by electricity to a distant mart, and possibly our anchor-ice experience, as affecting central-station plants, may be useful. If such be the case, it is yours.

JAMES W. CARTWRIGHT, Jr.

No. 2.—Is there any commercially practical method of removing or neutralizing sulphur in coal when the percentage is so great as to cause rapid deterioration of stack and breeching?

No. W. S. BARSTOW.

There is no practical method of removing or neutralizing sulphur in coal to prevent rapid deterioration of stack and breeching. This problem has been given careful consideration by some of the largest ore-smelting concerns in the country. All have been compelled to abandon the use of iron stacks and breeching and to substitute brick. The quantity of sulphur products produced by one smelter has become so large as to threathen the health of the neighboring inhabitants. The smelter company has decided to put in a brick conduit and carry the products of combustion nearly two miles from the smelter, discharging them through a stack on a hill. Sulphur burns to SO_2, and SO_2 without the presence of water should not attack iron. By covering the stack with non-conducting material, to prevent condensation of the water suspended in the flue gases, the life of the stack might be lengthened.

H. S. RUSSELL.

No. 3.—Under what conditions has it been found, in actual xperience, to pay to mix anthracite with soft coal?

We have found it advantageous to mix anthracite rice or culm with bituminous coal in the proportion of one-half anthracite and one-half bituminous for average work on boiler, making the amount of bituminous more or less with increase or decrease of load. The coals should be well mixed before placing on the fire. It requires considerable experience on the part of the fireman to handle the mixture to the best advantage. A fireman who has been accustomed to firing bituminous coal is apt to use the slice bar too vigorously and permit the anthracite coal to run through on the grates in large quantities when the coals are not well mixed before firing. JAS. E. PYLE.

We have in use one Babcock & Wilcox 175-hp and one Hogan 125-hp boiler. Our stack is of iron, 102 feet high from ashpit to top; four-foot opening. We get the best results by mixing one part soft coal to three parts hard coal, No. 3 buckwheat. With No. 1 buckwheat at $2.50 per ton, we burned three tons per night, equal to $7.50.

With soft coal at $3.60 per ton, No. 3 buckwheat at $1.25 per ton, and mixing one part soft coal (90 cents) with three parts No. 3 buckwheat (96 cents), the cost was $1.86 per ton mixed. We burned three tons per night, saving, by mixing, the difference between $7.50 and $5.58, or $1.92 per night, or 64 cents per ton.

FRED. B. SHARPE.

By mixing the two kinds of coal in about equal parts, we found that the aggregate daily consumption was practically no greater than when using all soft coal. With soft coal at $4.80 and buckwheat or birdseye at $3.30, the net cost of coal is reduced about 75 cents per ton.

GARDNER ELECTRIC LIGHT CO.

During the anthracite coal strike last fall and winter we were compelled to burn anthracite screenings (birdseye) with soft coal, and we found that by mixing two parts of soft coal and one part screenings and firing light and often, we were able to burn it with the following results: The price of coal, delivered, was: soft coal, $2.65; screenings, $1.65 per ton. We burned three tons of soft coal, costing us $7.95, during a run of 14 hours. Making the same run with coal mixed, two and one-third tons of soft coal and one and one-third tons of screenings were required, costing us $9.26. Assuming load and conditions to be the same, this means a loss to us of $1.31, besides handling one ton of coal extra and a larger amount of ashes. Considering also the extra coal and ashes that it would be necessary to handle, it is plain that it would not pay to mix soft coal with screenings under our conditions.

W. M. BELL.

No definite statement can be made regarding the use of mixed fuel. The only correct way to determine the advisability of using mixed fuel is to make actual tests in the furnaces where the fuel is to be burned. The conditions that give the greatest evaporation for one dollar are the ones to be maintained.

J. D. A., N. Y. ED. CO.

Under actual evaporative tests made with horizontal return tubular boilers, hand-firing, chimney draught .65 inch, I have obtained the greatest evaporation of water per pound of coal by mixing 25 per cent anthracite (buckwheat size, so-called) with 75 per cent soft coal, "run of mine," good quality. This mixture gives best results, with rapid combustion, light but frequent firing, and not over four inches of coal on the grates. Heavy firing with this mixture will deaden fires. This mixture of coal will prevent a heavy volume of black smoke. Comparative tests made with soft coal only, same grade and quality as used in above test with anthracite, gave two-and-a-half per cent less evaporation. JOSEPH HANSON.

No. 4.—Is there any simple method of determining the relative advantages of different kinds of coal, without resorting to a long test under the boilers, under working conditions?

There is no simpler method than the analyzing of the coal, which requires laboratory apparatus. W. S. BARSTOW.

A simple and convenient method of determining the strength and characteristics of different kinds of coal, is to test samples in a Parr calorimeter, which will give the heat value of the sample with great accuracy. By heating another sample of the coal in a covered crucible, the gas will be distilled off, so that by the difference in weight before and after distillation the amount of volatile matter can be determined, and an inspection of the residue left in the crucible will show at once whether or not the coal will coke. If this sample be again heated in an open crucible, all of the combustible will be burnt off, leaving nothing but the ash. An inspection of this ash will show whether the coal will make clinkers or dry cinders, and the weight of the ash will determine the percentage of ash in the coal. The entire testing outfit, including weighing balances, will cost about $150, and any engineer competent to take charge of a lighting plant can easily learn in a few hours to make this test. W. L. ABBOTT.

A calorimeter measurement of different coals should indicate their relative values. The Parr calorimeter costs about $85, and gives satisfactory results. After determining total heat of combustion by calorimeter measurement, some allowance should be made for the loss of heat that would result from the use of those coals containing a large proportion of hydrogen or a large proportion of moisture, as the gases must be discharged above the condensation temperature of water. Each pound of water carried out of the flue will contain about 1270 B. T. U., while a pound of ordinary flue gas would contain only about 100 B. T. U. C. W. HUMPHREY.

A working test of at least eight hours under actual conditions is the only correct method of determining the value of the coal. J. D. A., N. Y. ED. CO.

No. 5.—At what price per 1000 feet will it pay to use natural gas as against bituminous coal of fair steaming qualities at $1.50 per short ton?

Assuming that gas is to be used under the boilers to generate steam to operate steam engines, it will require 52,000 B. T. U., with a modern boiler equipment, to generate one brake hp-hour. Taking as a base natural gas with 800 heat units per cubic foot, it will require to develop one brake horse-power, 65 cubic feet at 10 cents per 1000. Fuel per hp-hour will cost .0065. Taking a steam plant using coal at $1.50 per ton and five pounds per hp-hour, your coal for this same amount of work will cost .00375, as against .0065 if gas is used for fuel.

On the other hand we will suppose you are going to use gas engines. Any recognized gas-engine builder will guarantee to operate on 12,000 heat units per brake horse-power with natural gas of 800 B. T. U. Fifteen cubic feet of gas at 10 cents per thousand equals one horse-power, or .0015. Therefore, natural gas of 800 B. T. U. at six cents per thousand, to be used as fuel for generating steam, will give you about the same results as coal at $1.50 per ton using five pounds per hp-hour.

Using gas engines operating on 12,000 heat units per hp-hour, you can operate with 50 per cent economy over coal, paying 12 cents per 1000 feet for gas. H. M. BEUGLER.

It is assumed that a fair steaming coal at $1.50 (in boiler-room) per short ton contains 12,000 heat units per pound, equal to 24,000,000 heat units per ton. One thousand cubic feet of natural gas contains 1,000,000 heat units; therefore one ton of coal contains the same number of heat units as 24,000 cubic feet of natural gas, making comparative cost as follows :

Coal per 2,000 pounds in boiler-room...	$1.50
24,000 cubic feet natural gas at .0625 per 1000..	1.50

All conditions being the same, natural gas would have to be obtained at six and one-quarter cents per 1000 cubic feet to equal coal at $1.50 per ton containing 12,000 heat units per pound. There would, however, be a greater efficiency in the use of natural gas over coal equal to 30 per cent.

An additional saving would be effected in labor, depending upon conditions—manual or stoker firing. Assuming that one fireman at $1.80 per day shovels 10 tons of coal, we have (assuming all other labor to be equalized) an additional charge for coal of 18 cents per ton. Twenty-four thousand cubic feet of natural gas less 30 per cent (increased efficiency) equals 16,800 cubic feet ; 18 cents added to labor for coal makes cost per ton $1.68. We now have with new conditions 16,800 cubic feet of natural gas at 10 cents per 1000 feet equal to one ton of coal at $1.68. JAMES W. DUNBAR.

Natural gas has a heating value of about 1000 B. T. U. per cubic foot. Fairly good bituminous coal has a value of about 14,000 B. T. U. per pound. It would therefore take 14 feet of natural gas to equal one pound of coal, or it would take 28,000 cubic feet of natural gas to equal one ton of coal ; so natural gas would apparently be worth 5.35 cents per thousand for steaming purposes. I am inclined to think that a much higher efficiency could be secured with natural gas than with coal, and saving in labor and higher efficiency would warrant paying seven cents per thousand for the natural gas. W. M. SITES.

At 27 cents. W. S. BARSTOW.

Natural gas at about six cents per 1000 feet is about equal to soft coal at $1.50 per short ton. These figures are based on practical considerations. If comparing on a theoretical basis, I think that a comparison of the heat values would be a proper one, as I can not see that any greater efficiency can be had with gas than with coal under boilers. Of course there is some saving in labor, handling of ashes, etc., which must be taken into account.

In Columbus, Ohio, I used natural gas to displace coke under artificial retorts for gas-making purposes. Here I found 26,000 feet of gas equivalent to one ton of coke. In a great many power-houses in Columbus we displaced the fuel used by natural gas and charged for our gas an equivalent of the cost of the fuel we displaced. The saving effected in labor was simply the inducement we used for getting the business. This was in the days when natural gas was considered inexhaustible. We would determine at various times after giving such flat rates, the price we were actually getting for our gas, and found the amounts varying from as low as four cents to as high as eight, but in no case did we make a refined test to give the exact quantity required to displace one ton of coal, and the figure of six cents given above is merely a round number that I feel will cover the case as well as any. E. E. EYSENBACH.

Our experience has been that the cost of using natural gas at six cents per 1000 feet is about 15 per cent greater than with coal at $1.50 per ton. This allows nothing for saving in labor, as we were obliged to retain the fireman on each shift, although he had very little to do except to look after the pumps, cut boilers in and out, clean boilers, etc. There are collateral advantages, however, in the way of freedom from smoke and soot and absence of corrosion from the lodging of damp ashes in inaccessible places, but it would be difficult to estimate them accurately in dollars and cents. EDITOR.

This depends entirely on the B. T. U. value of coal and the cost of burning it, such as labor, furnace maintenance, etc. For a comparison of the cost of fuel, natural gas at nine cents per 1000 feet would probably be about equal to bituminous coal at $1.50 per short ton. J. D. A., N. Y. ED. CO.

No. 6.—How much coal should a fireman be expected to handle in twelve hours?

If the duties of a fireman are understood to be the stoking and cleaning of his fire, a daily average of one ton per hour is about all that can be expected, but this depends in a great measure upon the quality of coal, kind of grates, temperature of room, etc. In special cases, where the fireman had nothing to do but the stoking, having a helper for cleaning fires and removing ashes, and where a fine grade of coal is used the writer has seen a fireman handle two tons per hour for six or eight hours daily. In a certain plant employing seven firemen, using a poor grade of coal running fully 20 per cent ash, the best monthly average shown in coal handled per man per hour was 1500 pounds per hour on 12-hour shifts, service 24 hours daily. PEORIA GAS & ELECTRIC CO.

Two thousand pounds an hour per man in an emergency. In ordinary heavy load 1800 pounds.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

We find that one fireman can handle about eight tons of coal per shift when firing by hand. We think conditions vary so much in different places that it would be impossible to say how much one man should handle. JAS. E. PYLE.

The fireman on a hand-fired furnace should fire from eight to ten tons of coal a day. I regard a 12-hour shift as altogether too long for a man at this work. In a large boiler-room, where several firemen are employed, I think the best results will be obtained by working the men eight hours, and have each fire between one ton and a ton and a quarter an hour. When a fireman gets tired he is not nearly so particular how the stoking is done, and for all the time he is at work beyond eight hours the amount of coal he wastes would easily pay for two firemen.

W. L. ABBOTT.

From 12 to 16 tons. J. D. A., N. Y. ED. CO.

No. 7.—Are automatic stokers more economical than hand-stoking in plants of less than 250-hp capacity?

Having run hand-fired furnaces for 14 years and automatic stokers for 10 months, we consider the stoker a luxury in a plant of less than 500 horse-power. Unless the increased interest, depreciation and repairs can be covered by labor saved by the stokers, the stoker in a small plant will not pay.

JAS. E. PYLE.

I do not think automatic stokers are so economical as hand-firing in plants of 250-hp capacity, provided intelligent hand-firing can be secured. This is particularly true in an electric-light plant, where the load fluctuates rapidly. Most stokers do not lend themselves readily to fluctuation in load.

H. R. WEBER.

Automatic stokers are no more economical on labor than hand-stoking unless the consumption of coal in the boiler-room runs as high as a ton and a half an hour, as one fireman, on a pinch, can handle as much coal as that in the hand-fired furnaces, while it would at the same time require one fireman to look after a stoker. W. L. ABBOTT.

The question of the economy of installing automatic stokers in a steam plant is one to be decided by the result of the comparison of the advantages and disadvantages derived from the use of them. The writer knows of a plant of about the size of the one under discussion in which a mechanical stoker is giving entire satisfaction. The fuel is a mixture of coal, coal dust and refuse, quite as poor a material to burn as can be imagined, but this machine burns it and keeps up a most excellent fire. The operator, or fireman in attendance, has instructions to keep the hopper of the stoker filled with the fuel and to pull a lever occasionally that operates the clinker pan. These duties are such as do not require the services of an experienced fireman, and this feature is therefore the source of some economy. This stoker is driven by a motor that is also used to drive a triplex pump, so the cost of operating the stoker is reduced to a minimum, as the expense of the motor is divided between it and the pump. This example, however, can not be taken as conclusive proof that mechanical stokers will in all cases be economical, as it is one in which the conditions are most favorable for the use of the stoker.

A case is cited of a large manufacturing establishment that had mechanical stokers installed in the boiler-room. It was noticed that the firemen did not appreciate the innovation, but were firing in the old-fashioned way. Upon inquiry it was found that with the stokers in use the men were compelled to shovel the coal into the fuel hoppers, which were at an inconvenient height above the floor level, thus entailing more effort than was required to throw the coal through the furnace doors lower down. The stokers without the needed overhead coal bins, and possibly necessary coal-conveying and elevating machinery, were in this instance just so much wasted investment, and what might have been a most economical arrangement was utterly spoiled because it was not carried far enough. In conclusion, the writer would say: Consider each proposition individually, and apply to each the solution that promises to be the most economical in its results. E. T. WALSH.

A good automatic stoker, properly attended to and handling the kind of coal for which it is designed, is more economical than hand-firing in any sized plant.

J. D. A., N. Y. ED. CO.

No. 8.—What has been the experience as to comparative cost of labor in charging coal under boilers by hand or with stokers; also, what comparative results have been obtained as regards efficiency? What is the comparative cost of repairs on a plant of about 1200-hp capacity?

It has cost the Chicago Edison Company in boiler-rooms having hand-fired furnaces about 25 cents a ton to charge the coal under the boilers, and when these same boilers were equipped with chain grates and overhead coal bunkers the cost was reduced to six cents a ton. The efficiency is about the same in either case, with a slight advantage in favor of hand-firing. The repairs are approximately 25 cents per horse-power annually greater with chain grates than with hand-fired furnaces. These repairs are principally on the brick arch.

W. L. ABBOTT.

The cost of firing boilers by hand or by automatic stokers will at the end of the year be practically equal when the cost of maintenance plus labor is equated for the stokers against the cost of labor plus maintenance of hand-fired grates.

H. G. STOTT.

Our labor for firing costs about 32 cents a ton on flat grates and about seven cents a ton with stokers. We believe that with the chain grates we are saving from two to five per cent in coal, due to the use of stokers, rather than new fire grates.

Repairs to grate and furnace on a 1200-hp plant, we estimate would be about $200 with flat grates as compared with about $1500 with stokers.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

I think about 25 per cent in actual firing, but other labor to be charged to stokers will nearly cover the 25 per cent. I should say the efficiency of a good stoker over hand-firing would be nearly 10 per cent. W. B. BLOXHAM.

My experience in charging coal under boilers with stokers is as follows: In a plant consisting of four 250-hp Babcock & Wilcox boilers, equipped with American stokers, with induced draft, we found the saving over hand-firing to be approximately 30 per cent, using run of the mine coal which costs $2.35 in the bin, from which we were enabled to obtain the equivalent of 11.25 pounds from and at 212 degrees. The cost of renewals and repairs to the stoker was equal to 25.8 pounds of castings per horse-power per year. The stokers consumed approximately two per cent of the steam to operate them. On an overload test they would run to 100 per cent over their ratings without any unsatisfactory results. The stokers cost approximately $3.50 per horse-power installed.

We have no data in regard to hand-firing in this plant, therefore can not give costs of same. G. B. LELAND.

This is a very broad question, and no definite answer should be given. The cost of labor for charging coal in the boiler would be with the stoker from one-third to one-half of what it would be by hand. The efficiency of the stoker, working under the conditions for which it was designed, would probably be from five to ten per cent above the well-managed hand fire. The cost of repairs would probably be from two to three times as great with the stoker as with the hand fire.

J. D. A., N. Y. ED. CO.

No. 9.—What is a simple and cheap arrangement for getting ashes out from under boilers; also for loading same on cars or carts from a station of about 1200 horse-power?

The use of hoppers and industrial railway.

W. S. BARSTOW.

We should consider it doubtful whether a station of this capacity could afford to use anything but carts or barrels.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 10.—What is the best kind of gasket for use on handholes and manholes of a boiler?

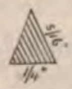
A tubular gasket will make the best joint, and is easily applied.
A. O. FRETZ.

Up to three years ago we used rubber gaskets on manhole and handhole plates on our boilers. At that time, however, we tried asbestos and found it much superior in that it will keep the manhole or handhole steamtight longer and at less expense than the rubber, especially with the dropping and raising of steam very often on the boiler. We use a gasket composed of asbestos stock one-sixteenth of an inch thick, and enough of the thicknesses together so that the gasket will be from one-eighth to three-eighths of an inch thick, and with this we do not experience any difficulty. Our steam pressure is 160 pounds, and varies but very little except by reason of cutting boilers in and out of service on account of the different ranges of the load.
W. P. HANCOCK.

We have two 250-hp Heine boilers, and we have always used rubber gaskets, both on the handholes and manholes. I have recently ordered some rubber gaskets for the handholes. Before ordering I considered the asbestos gasket, but as asbestos gaskets cost four or five times as much as rubber I did not think that the additional expense was warranted. I have no doubt that the asbestos gasket is a good thing and will outlast several rubber gaskets. I have had no experience with them, but I doubt if they will outlast four or five rubber gaskets.
F. ELLWOOD SMITH.

Red rubber, which will not vulcanize.
N. LEDFORD.

We have used lead gaskets with good success. We find that gaskets differ a good deal according to the water that is used.
C. F. SNYDER.

We use for handholes on the Heine boiler a lead gasket (section ) four and one-eighth inches in diameter outside, three and five-eighths inches inside, which we make in a hinged cast-iron mould, similar to the old-style bullet mould, the gate being on the outside of the ring. The ring is poured vertically and a vent is necessary on either side of the gate. The lead should be very hot, and the mould must be heated before beginning to pour, otherwise the lead will chill before filling the mould.

These gaskets make a perfect joint, and require little or no attention after the men understand how to handle them. When placed, a slight pressure should be put on the bolt, and as steam is being raised the bolts should be tightened only enough to stop leaks. The firemen make the gaskets at odd times. The lead is used over and over, making the cost very slight.

JOHN B. GARDEN.

For an Eclipse manhead the bearing is small, and a rubber gasket will become crushed and will soon squeeze out. I therefore use a composition lead gasket, making it comparatively hard or soft, according to the pressure and the temperature. For an old-style manhead, having a large bearing, a good quality of cloth-inserted rubber gives satisfaction. By coating the under side with white lead and the top surface with graphite mixed with cylinder oil, it can be used over many times and will last from six months to two years. W: M. CRAIG.

The best gasket for use on manholes of a boiler is a rubber ring cut from sheet rubber (which can be bought at a very low price), coated with graphite grease on each side. This never fails to make a good joint, and very seldom gives trouble by leaking; it is easily removed, as the graphite prevents the rubber from sticking to the iron. JAS. E. PYLE.

Our experience has been that we obtain better results from the use of rubber gaskets for a Heine boiler, with the cloth insertion. With the copper gasket we had to use asbestos wicking in order to make a tight joint, and we found that we could use the gasket but once; we also found that the lead, as well, could be used but once, although it did not require the use of asbestos as in the case of the copper gaskets.

L. R. WALLIS.

There are two considerations in regard to gaskets. The first is reliability and time, and the second is economy. Rubber is, without doubt, the best available material for a gasket, and as the best grades can be had in several forms and are sold by the pound, the weight of the gasket is a very important factor. A well-cut gasket will make a good, tight joint, but has the disadvantage of requiring time for cutting, care in fitting, and the loss of the scrap. A moulded gasket is good, and costs less because there is no scrap ; but as manholes and handholes often differ a little in size and shape, this is often the cause of a bad fit, and should there be unevenness in the surface it often happens that a leaky place requires attention when the boiler is being filled, and if time is short it is an extra bother and expense to let water out when you are in a hurry for steam. There are a number of soft-rubber tubular gaskets on the market, which cost but little. They fit everywhere—every size and shape—and always make a tight joint. They are the quickest, cheapest and most reliable, and you have no scrap at all, and if time is an object they are in every way the best, as they are always ready. H. A. HAMPTON.

After six years' experience with different gaskets for the Heine boilers, we find that G. W. Knowlton gaskets for handholes remain tight the longest. Those we have tried are like all the other gaskets for this particular place, in that they can not be used the second time. The cost of these gaskets is about three cents each. We have also used a gasket made by the Day Rubber Co., of St. Louis. This gasket does not remain tight one-half so long as the Knowlton gasket, but will remain tight under ordinary conditions until the boiler requires cleaning, which would be about once in six weeks. The price of this gasket is about nine-tenths of a cent. Our deduction from the above is that it is better for us to use the cheap Day gasket at nine-tenths of a cent each, which remains tight from four to six weeks, but is not good after that. For the manhole, we find that the moulded lead gasket is the best thing. This gasket is supplied by the boiler company. We have had the same gasket on one boiler for four years, and during that time the manhole plates were probably removed 50 times from the boilers. WELLES E. HOLMES.

I consider asbestos the best. W. B. BLOXHAM.

This company uses Guillott for the front plugs of Heine boilers. These cost us about two cents each, less a credit of one-half cent for old metal, making a net cost of one and one-half cents each. They can be taken out and put on twice before they are useless. These gaskets are tight when the boiler is up to pressure, but when the pressure runs down they always leak, but will stop leaking when the pressure is raised again.

On the back plugs of Heine boilers we use McKim gaskets, consisting of a flat piece of rubber inclosed in a copper shell. These gaskets will last indefinitely without leaking so long as they are not disturbed, but if the plugs are taken off new gaskets will be needed. The cheaper gasket is used for the front plug, because these plugs are taken off every month or so for boiler cleaning, but the back plugs are not disturbed oftener than once a year.

W. L. ABBOTT.

In my experience, the best kind of gasket is the rubber gasket furnished by the Heine company.

UTAH LIGHT AND POWER CO.

We have found the Kearsage asbestos metallic packing to give about the best general satisfaction for manholes on Heine boilers. The cheapest gasket for handholes that we have thus far found, which at the same time gives fair satisfaction, is lead. The handholes, however, require very close attention, especially where boilers are quite frequently put in and out of service.

W. J. GREENE.

I have found a common four-ply rubber gasket to be the best and cheapest for use on handholes and manholes of boilers carrying a pressure of not over 110 pounds. If handled with care it will last from one to two years, plates being removed and replaced once a month when boiler is shut down for cleaning.

JOSEPH HANSON.

No. 11.—What is the best method of protecting and preserving the iron arch and dead-plate castings used in boilers?

The best way to preserve the iron arch is to prevent the fireman from prying against it in stirring up his fire. To save the dead plate on doors, he should keep his fire back from the dead plate and not allow red-hot coals to lie on it, burning the plate as well as the front doors. Keep the fire back under the boiler, not on the dead plate, where it does more harm than good.

PERRY ELECTRIC LIGHT AND POWER CO.

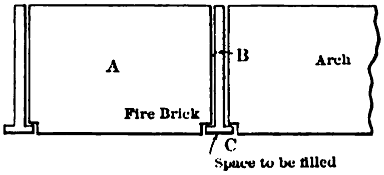
Whitewash with fire-clay every time boiler is cooled.

N. H. LEDFORD.

I know of nothing better than the T-shaped arch. By cutting off the corners of the bricks so that they will project a little below the iron and plastering with fire-clay or asbestos cement, the T-shaped arch will last a long time.

I know of no way to protect the dead plates. They should be made of a composition similar to stove plate, as common gray iron burns out much the quickest.

W. M. CRAIG.



A very good method of protecting the iron arch of a boiler is to have it made hollow and have the feed water to the boiler pass through it; also to have a circulating pipe connecting the bottom of the boiler and the feed-pump end of the arch, with a check valve inserted to prevent the water from flowing into the bottom of the boiler, but permitting the water to circulate from the bottom of the boiler through the arch when the pump is not feeding. We have had arches of this character in use about 10 years, without any repairs whatever to either arch or smoke-box wall.

As for the protection of the dead-plate castings, we set our grate bars about an inch above the dead plate and lay a short piece of plate in the fire-door, fastened with two bolt-taps through the original dead plate. These plates protect the dead plate and are inexpensive to change when in bad condition. This protects the dead plate well enough so that it will not have to be removed during the life of the boiler.

JAS. E. PYLE.

Do not use any iron arches.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

A brick arch, or perhaps a good circulating water arch.

W. B. BLOXHAM.

Arch plates should be no wider than dead plates, but the entire lining of fire-doors—that is, side plates, arches and dead plates—should be nearly the same in width; if there is any difference, the arch should not be as wide as the dead plate, as the arch is subjected to a more intense heat, and should therefore not extend over the grate. Put at least four inches of fire-brick between the edge of the dead plates and the end of the grate. Arch and side plates should flare so as to become a much larger opening near the grates than at the door; this will prevent the fuel from striking the plates when being thrown into the furnace. However, most furnaces are built more or less in a standard way. Then comes their protection, which is of the utmost importance. As in all engineering matters, constant diligence is the price of success. A careful fireman is the life of the furnace, boiler and fuel. Fuel should not be allowed to lie and burn on the dead plate, for it makes but little steam, burns up the castings and doors, and heats the fireman, etc. The greatest protection to these parts consists in cleanly men, fires spread evenly over the grates, and an even draft. A great pile of fire in the front door is the death of firemen, steam and castings. The grate is the place to burn fuel when you want steam. H. A. HAMPTON.

My experience has been that the best way to protect iron arch and dead-plate castings in boilers is to eliminate them entirely from the boiler-setting, substituting a fire-brick arch, jambs and dead plate of very simple construction, but which will last for years, or as long as any other part of the setting above the grate.

The arch is constructed of standard tongue-and-groove arch fire-brick. The jambs should be of one solid fire-brick each, moulded to order. The dead plate, or hearth, consists of two courses of brick with broken joints resting on T-irons; brick laid at right angles to the hearth. The first or lower course consists of hard red brick laid in cement. The second or top course, level with the grate, consists of selected fire-brick, perfectly straight, laid dry and tight with cement joint between fire and red-brick courses. The hearth extends the entire width of the setting upon which the jambs are set. There being no heat of any account applied to the red-brick course, it remains solid and intact. The fire-brick course, being laid dry and tight, will become completely wedged by expansion of the brick when heat is applied to the boiler. There being no wear and tear on the lower or red-brick course, the hearth remains perfectly airtight, even in the event of a brick of the top course being broken; in which event it can easily be replaced. This, though, has not happened to any of our hearths, some of which have been in use three years. Part of this construction being original with us, and there being no patents on it, we shall be pleased to answer any question in relation to it.

L. W. BYERS.

No. 12.—Under what conditions and to what extent are rocking grates preferable to plain grates for boilers?

The only experience we have had has been with one Babcock & Wilcox 600-hp boiler. We changed from rigid to shaking grate, and found better consumption of coal and less labor. We believe in rocking or shaking grates.

GEO. B. LAUDER.

Rocking or shaking grates are superior to stationary grates for several reasons, particularly with the cheaper grades of coal. With a stationary grate the use of the slice bar is very often resorted to, thereby raising up the clinkers into the fire, and when the heat is intense they become melted and run down into the grate bars, closing them up. At the same time, while using the slice bar the doors must be open, thereby reducing the efficiency of the coal, while a rocking or shaking grate can be operated with the fire-doors shut, shaking part of the clinkers through into the ashpit and allowing a fire to be run longer without cleaning.

W. M. CRAIG.

When you want to raise steam quickly it would be advisable to have rocking grates to the extent of 25 per cent of the total installation; also where you want to carry maximum capacity for a long time and have not otherwise a chance to clean fires properly.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 13.—What is the best method for removing hard scale from a return tubular boiler?

We have two strata of well water that, if used in certain quantities of each, keep our boilers perfectly clean, as we have determined by experience. One of these wells is strongly impregnated with lime and some mineral, and if used alone it will soon scale up a boiler. The water from the other well contains strong soda and some magnesia, together with other properties, and by using the two in combination we avoid scale entirely. Formerly, we used various compounds for this purpose; on one occasion we used kerosene with very good results, but we do not advocate this, because of the bad effect it has on the cylinder and packing of a high-speed engine. It greatly increases the difficulty in maintaining the steam-pipe joints tight.

S. S. INGMAN.

We have no return tubular boilers. When we had them we used kerosene and soda to good advantage.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

If there is very much scale in a boiler, in my opinion the right way would be to take out the tubes and thoroughly clean both shell and tubes with a round-faced hammer. When a compound is found that will remove such scale, there is great danger of bagging the boiler, or even worse, for when the scale drops down the circulation carries it to the front of the boiler, where the heat is the most intense, and which is the worst place in which it could be deposited. W. M. CRAIG.

We use kerosene daily, and before cleaning the boiler we put in a good dose of potash. FRED. B. HUBBELL.

It depends altogether upon the quality of the scale. A good rotary cleaner is a very good thing for this purpose.

W. B. BLOXHAM.

Analyze the scale, and if a solvent can be found that will not injure the boiler, use that; if not, use a man with a hammer and chisel. J. D. A., N. Y. ED. CO.

No. 14.—What are the advantages and disadvantages of superheating steam? What is the necessary equipment per horse-power, and can it be readily applied to existing boilers?

The cost of necessary equipment per horse-power for superheaters should be about $3.00 There are makes of superheaters that can be applied to existing boilers. The advantages are in economy of steam consumption in an engine by securing perfectly dry steam in cylinder by superheating 150 degrees Fahrenheit. The disadvantages are in the additional quality of pipe-covering, for preventing loss of the superheat, and well-made valves, etc. W. S. BARSTOW.

The advantages are all those due to absolutely dry steam and, in general, the advantage of doing away entirely with cylinder condensation, if the superheat is high enough. This company is using 100 degrees superheat with 160 pounds pressure on gridiron valve and is having absolutely no trouble. We know of no disadvantage.

We are using .9 of a foot of superheating surface per horse-power of boiler. This is the Babcock & Wilcox superheater and can be applied to any Babcock & Wilcox boiler.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The advantage to be derived from the use of superheated steam is increased economy in the heat and hence in the coal required per i.h.p. per hour. Economy is the central idea involved in the use of superheated steam. This gain arises through an improvement in the conditions that limit the economy of the steam engine. They are chiefly the following: (1) The so-called limiting thermo-dynamic efficiency, and (2) the partial condensation of the steam as it enters the cylinder. According to the first of these, it appears that even in an ideally perfect engine only a portion of the heat that comes to the cylinder can be transformed into useful work, and this fraction will be the larger as the temperature range through which the steam is worked is the wider; that is, as the temperature at admission is higher and the temperature at exhaust lower. The usual condenser pressures furnish a natural limit to the lower temperature, but there is no such barrier to the elevation of the upper temperature and to a gain in economy in this way. Superheating is, then, a method of raising the temperature of the steam at admission, and hence improving the possible ideal efficiency without at the same time too extreme corresponding rise in pressure.

The second limitation, as a consequence of which a considerable part of the steam may be condensed on its first admission to the cylinder, is one that prevents the operation of steam under any high degree of expansion in any one cylinder. It is chiefly to decrease this loss that the expansion is carried on in compound, triple or quadruple expansion engines, as in the best modern practice with saturated and moist steam. Superheated steam, however, is not in part condensed by the abstraction of a small quantity of heat as is the case with saturated steam. If, indeed, the degree of superheat can be made sufficient to prevent the steam from falling to the saturated condition at any time during its passage through the engine, condensation will be prevented and the serious loss due to the interaction between the walls of the cylinder and the steam will be very much decreased.

A third possible source of gain may be mentioned; this is the increased tightness of piston and valves and the decreased amount of leakage with superheated as compared with saturated steam.

It may be accepted as demonstrated by numerous tests during the past few years with steam superheated from 200 to 250 or 300 degrees above the temperature of saturated steam, that the gain in economy should be from 12 to 15 and even 20 per cent, varying with the special conditions.

One or two consequences of these general principles may be noted: First, if the degree of superheat were sufficient, the simple engine could be made the equal in economy of the multiple expansion and the complication and greater cost of the latter type might be avoided. Actually, this is more than could be expected, but it may be fair to expect that with a full realization of the possibilities of superheated steam there will be little need to go beyond the compound type, at least so far as economy is concerned.

Second, it should not be forgotten that in the results of trials of engines using superheated steam as compared with those using saturated steam, the number of pounds of steam is not a fair basis of comparison, since there is much more heat in a pound of superheated steam than in a pound of saturated steam. The only fair basis of comparison in such, as in all cases, in fact, is the reduction to heat units per i.h.p. per hour.

The chief difficulties or disadvantages that have arisen are of two kinds: the corrosion or burning out of the superheaters, and trouble with the lubrication and general operation of an engine with superheated steam. These troubles are, however, mechanical, and they are being met and overcome in highly satisfactory manner in various systems before the engineering public, and in particular as developed within the past few years in continental Europe.

A description of the necessary equipment and it's application to boilers of varying types, would require space exceeding the proper limits of a brief discussion such as the present. The engineering press during the past three years is rich in matter relating to the generation and use of superheated steam. The number of types of superheaters is exceedingly large. Some are independent of the boiler, and may therefore be readily used in connection with existing boilers of whatever type. Others are intended to operate with the boiler and in some cases could be adapted only with difficulty to boilers already installed. In other cases such adaptation could be made without undue expense, and the gain from superheated steam thus be obtained with a minimum of disturbance to the existing plant.

W. F. DURAND.

The advantage is mainly increased economy ; different boilers require different equipment. They can be placed outside of boiler and separately fixed. They can be applied to existing boilers, but I don't think it is good engineering.

W. B. BLOXHAM.

Advantages: The principal advantage in the use of superheated steam is the prevention, to a greater or less extent, of initial condensation in the cylinder, thus increasing the work done per pound of working fluid. Its use enables the designer to reduce the size of the steam mains, thereby cutting down, relatively, radiation and friction losses. If the steam is superheated at release, less heat is given out by the cylinder walls to the exhaust, but best results are obtained with the steam just dry at release. Under this last condition jackets are of no value except for warming up the engines, and they are usually omitted, the temperature of the cylinder walls being much higher than with the use of saturated steam. There is also a further gain in economy due to the fact that films of water do not form around the piston rings and rod packing, and there is little of the customary leakage that is due to these films of water.

Disadvantages: Special valves and stuffing boxes are required and a special high-test oil must be used for lubrication. There is usually a greater friction loss in the cylinder, also a greater range of cylinder temperature. A higher class of steam piping must be employed, and the increased temperatures mean increased troubles with expansions and joints, in both piping and engines; also a slight increase in the first cost of this portion of the plant. The superheating surface in the boiler and more high-pressure valves and steam piping must be kept in order. A better quality of non-conducting pipe covering is required.

Ease of Application and Necessary Equipment: Superheaters can be readily applied to all modern types of boilers, and many of the up-to-date boiler manufacturers have superheating arrangements worked out and are in a position to contract to install and guarantee them. Under varying conditions the best results are obtained from the use of from seven to twenty degrees of superheat for each per cent of moisture in the steam at the point of cut-off in the cylinder, the difference being due to the design of the engine and the steam pressure. Superheating surface attached to a boiler costs about twice as much as boiler heating surface per square foot, and separately fired superheaters cost about three times as much per square foot of surface. About one square foot of superheating surface to seven square feet of boiler heating surface is the usual ratio for 140 degrees to 200 degrees of superheat, and one to twelve for 100 degrees to 120 degrees superheat. The use of separately fired superheaters is advocated only in the case of very long steam pipes, the superheater to be located at the end of the line, near where the steam is to be used.

G. A. O., N. Y. ED. CO.

No. 15.—Are automatic feed-water controllers for boilers satisfactory in operation? Is it advisable to use them in small stations?

We believe not.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Automatic feed-water controllers have been in satisfactory use for some time. W. S. BARSTOW.

We consider automatic feed for boilers desirable in any plant, and a cheap device, which works very satisfactorily for a small plant using duplex pump for boiler feeder, is to put the steam-supply pipe through the shell of the boiler so that the opening is at the point where you desire to carry the water level. When the water is sufficiently high and supplies water to the pump, instead of steam, the pump will slow down until the water level drops below the opening. Arrangements should be made, however, so that steam can be supplied to the pump in the usual manner, so that the pump can be used independently of water level when desired. **S. S. INGMAN.**

Some automatic feed-water controllers are satisfactory and can be used in small stations. They should not be recommended unless the saving in labor due to their use would be considerable. **J. D. A., N. Y. ED. CO.**

No. 16.—How long should a three-sixteenths-inch unlined iron stack last under normal conditions of operation?

Our experience is greatly against the use of iron stacks. We recently had one give out suddenly a short distance from the top when there was no external evidence of weakness, even upon close examination. The matter might have been quite serious with us, and no external inspection would have warned us of the danger. **ALEX J. CAMPBELL.**

A chimney with a three-sixteenths-inch iron base and one-eighth-inch iron top rusted through in one-eighth-inch section and fell over in eight years from date of its erection. Two steel chimneys, one-fourth inch thick to the top, showed a reduction of one-half in six years. We should judge from this experience that the three-sixteenths-inch chimney referred to would last about 12 years if built of iron, and would be shorter-lived if built of steel. **JAS. E. PYLE.**

It depends altogether on the care taken of it and on the temperature of escaping gases. **W. B. BLOXHAM.**

A three-sixteenths-inch unlined iron stack should last, if properly painted and taken care of, at least 20 years. The corrosions at section joints are most to be feared, and can be taken care of by periodical inspection and painting. Where soft coal is burned, the life of the stack would probably be somewhat shorter, owing to the high percentage of sulphur in gases.

J. P. S., N. Y. ED. CO.

No. 17.—What is the best paint for stacks and breeching, and what is the best method of applying it?

4 parts fine graphite
4 parts powdered charcoal
2 parts oxide iron
Mix with boiled linseed oil and apply with paint brush.

N. H. LEDFORD.

Several years' use of oil tar, the tar by-product of water-gas manufacture, has proved it to be a very satisfactory coating for iron stacks. PEORIA GAS AND ELECTRIC CO.

The Woodbury hot iron paint.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

My experience indicates that in the interior, away from the seashore, there is very little difference between coal tar, bitumastic, graphite, and similar paints properly applied ; in each case assuming, of course, that the stack is of proper dimensions for the work it has to do. I also find that the proper temperature of the stack at which the paint should be applied, to guarantee preservation of the metal and to get the greatest life out of the paint, is at the point where the chill has been taken off. The paint can then be well rubbed in and a body retained. If it is cold, it will not take the paint properly ; if it is hot, no matter how careful or honest the workman is, it will be an impossibility to retain a uniform body of paint on the stack. Joints should be cemented on the inside before painting, and paint applied with a wall brush and well rubbed in. The painting should *not* be done by contract.

Along the seashore we have a different proposition with relation to stack painting, on account of the salt moisture. We find that paints having a long life in the interior fail to a certain extent on the coast. We have tried many different paints, applied in different ways, but have been more successful with Raney's enamel iron paint than with any other. No matter what paints are used, stacks and breechings should be of proper temperature when the paint is being applied, joints cemented on the inside, and paint thoroughly rubbed in. Where rust has developed, it should be removed before applying the paint.

L. W. BYERS.

The best paint we have ever found for painting stacks and breechings is made by Robert Watt, of Denver, Col. It contains asphaltum, tar and graphite, and the tar and asphaltum compounds are those that distill off above the temperature at which the stack will be operated. The paint is bright, does not run, and does not crack. W. T. BAKER.

Graphite paint. W. B. BLOXHAM.

The best paints for stacks and breeching would seem to be the graphite paints by the several makers, the value of the paints being determined largely by the method of application. To secure the best results with a paint, it is necessary to clean all loose scales thoroughly from the surfaces to which it is to be applied, and apply the covering material in two or more coats, with stiff brushes, working the paints well into the joints about the rivets. J. P. S., N. Y. ED. CO.

No. 18.—Is there any satisfactory appliance for reseating small valves without removing them from the line?

There are many satisfactory appliances for reseating small valves without removing them from the line; they are made by steam specialty companies. W. S. BARSTOW.

Use valves with a removable disc.

FRED. B. HUBBELL.

Jenkins Brothers make a moderate-priced tool for reseating flat-seated valves. Valves from three-quarters of an inch up may be reseated with this tool, and I understand that it gives satisfaction. It is, of course, useless for conical-seated valves. For the latter class of valves a tool is made by the Leavitt Machine Co., Orange, Mass. I have heard good reports of this tool, but it costs from $50 up. It will also reseat flat-seated valves. Capacity for both kinds, three-quarters of an inch up. These are the only tools of the kind of which I know.

TOWNSEND WOLCOTT.

There are several machines manufactured which will do the work satisfactorily. The writer uses the Morse & Dexter valve-seating machine. E. W. FURBUSH.

Have used Morse reseating machine for repairing valves without removing from the line, and consider the same very satisfactory. G. B. LELAND.

There are many satisfactory valve-reseating devices on the market, results obtained from which are dependent entirely on the skill of the operator. This applies to globe valves. There is, we believe, no reseating device for gate valves.

J. P. S., N. Y. ED. CO.

No. 19.—What progress has been made in the development of the steam turbine as applied to the operation of dynamos?

One turbine of 15-kw capacity driving a dynamo has been in service satisfactorily for a little over a year. Several of 500 and 600-kw capacity are in service. Some turbines have been built as large as 5,000-kw, but have not yet been started.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

At present there are only two types of steam turbines that may be regarded as commercial machines, viz.: the Parsons and the De Laval. With nearly 20 years of history behind them, I think it might be reasonably claimed that both types have passed the development stage, and have become standard articles of manufacture and trade. Progress at present is largely in the direction of increased confidence on the part of the buying public and increased manufacturing facilities and improved mechanical processes on the part of the builder. I do not wish to be understood as saying that no further advance will be made in the art, but rather that I do not expect any sensational developments that will, without warning, make existing machines antiquated and obsolete.

One who has closely studied the history of steam turbines, and is acquainted with the industrious way in which inventors have worked at the problem for the last hundred years, will not be so much disturbed by the redoubled energy that has been stimulated by the practical success of existing machines. An analysis of many schemes recently put forth as new and revolutionary, clearly shows them to be reinventions of old principles disclosed in patent-office drawings of 50 and 60 years ago. In the steam turbine from now on, I look for the gradual improvement common to all things. We may eventually get somewhat better efficiencies; or we may from time to time make improvements that will in a measure simplify the construction and reduce the cost; but, broadly speaking, I consider the steam turbine, as regards its development, as certainly being on at least as stable a footing as are the present accepted methods of generating and distributing electricity. There will doubtless be many new and radical designs offered to the public. but these designs will require several years of probation under the ordinary conditions of service obtaining in the average power plant before they can be entitled to full confidence, as we who build machines can see nothing but the good points, and we are obliged to turn them over for a season to you who operate them, to have the weak points picked out for us, before we can finish the job entirely.

To summarize briefly, the present status of the steam turbine in the United States is about as follows:

1. Units of 400-kw capacity have been in constant operation for four years without developing any mechanical weaknesses or showing any signs of deterioration, either in respect to wear or efficiency.

2. Units as large as 1,500-kw capacity have entirely passed the probation period. The subsequent order for two turbo-generator sets for plant extension by the purchasers of the largest turbine yet installed, is a sufficient commentary on its general performance.

3. The results of experience have been such as to justify conservative manufacturers in making the large capital outlay necessary for the production of machines of 5,500-kw nominal capacity. The construction of such machines of the Westinghouse-Parsons type is well under way, and they have found ready purchasers in advance of their actual production. It is confidently expected that units of this size will be in operation before the next annual convention of this association.

4. As regards economy, it is stating the matter most conservatively to say that in point of steam consumption per kilowatt of electrical energy delivered at the terminals of the generator, the turbine is not surpassed by any type of reciprocating engine. In the sundry matters of cost of installation, up-keep, oil, attendance, repairs, etc., which count heavily in general commercial station economy, its advantages are too patent to require explanation.

5. Except in the smaller sizes, where speed-reducing gears can be used advantageously, it has thus far been undesirable to couple direct-current generators to steam turbines, on account of commutator difficulties resulting from the prevailing speeds of prime movers of this description.

6. With turbo-alternators, all difficulties in parallel operation are entirely eliminated.

7. There has been one serious accident to a 400-kw turbo-generator, at the factory of the Yale & Towne Manufacturing Co., at Stamford, Ct., within the past year. Considerable prominence has been given to this accident, and it is only fair to call attention to the fact that it was due solely to a hidden defect in a steel forging, and was entirely independent of any question of design or construction of the machine itself. Accidents of this nature are so common with reciprocating engines that they no longer excite more than a moderate degree of interest. The accident to the turbine set caused no damage to person or adjacent property, which can not be said of many engine accidents arising from a similar cause. The owners' order of a duplicate set since the accident is perhaps the briefest and the most forcible explanation of the matter that could be made.

HENRY E. LONGWELL.

No. 20.—What is the steam consumption in pounds per hp-hour in steam-driven turbines operating against a back pressure of from five to seven pounds; initial pressure at the throttle, 150 pounds to 175 pounds?

Steam consumption in steam-driven turbines is not based upon pounds per hp-hour, as there is no way of indicating. The performance of the steam turbine in general is as good as that of the best type of engine for the same conditions.

W. S. BARSTOW.

The steam consumption in pounds per brake hp-hour, with steam-driven turbines operating against a back pressure of five pounds and with initial steam pressure of 150 pounds, was recently given us by a prominent manufacturer as between 34 and 36 pounds. Operating under these conditions, special arrangements have to be made to keep the oil in the bearings. With steam turbines it seems to be essential to maintain a high vacuum to obtain good efficiency. EDITOR.

I do not know of any direct experiment that has ever been made to determine this point. We have a good knowledge of the steam consumption of turbines exhausting against atmospheric back pressure, and also of condensing turbines running under various conditions of vacuum. From the data obtained we can estimate with full confidence what results are to be expected under unusual conditions.

A turbo-generating set will transform from 50 per cent to 52 per cent of the total available energy of the steam into electrical energy. For example: A pound of dry saturated steam working between limits of 150 pounds initial pressure and a vacuum of 28 inches, has 322 B.T.U. available for doing work. The heat equivalent of a hp-hour is 2545 B.T.U., and consequently the steam consumption of a perfect engine would be 7.6 pounds per hp-hour. An actual engine converting 50 per cent of the available energy into work would therefore require 15.2 pounds per electrical hp-hour, which agrees closely with actual tests.

A pound of dry saturated steam working between limits of 150 pounds initial pressure and atmospheric back pressure, has 173.5 B.T.U. available for conversion into work. The ideal steam consumption is, therefore, 14.7 pounds per hp-hour. Assuming, again, an efficiency of 50 per cent, the actual steam consumption would be 29.4 pounds per electrical hp-hour. As a matter of fact, as the difference of pressure between admission and exhaust grows less, the total efficiency improves slightly, and in the case of atmospheric exhaust the actual steam consumption is nearer 29 pounds. Making a similar calculation for seven pounds back pressure, the initial pressure remaining the same, we find 149 B.T.U. available in each pound of steam, corresponding to an ideal consumption of 17 pounds and an actual consumption of not more than 34 pounds, with a strong probability that it will not exceed 33 pounds.

It must be understood that the results given above are only for turbines designed especially for the given conditions. It is impossible that a turbine designed to give the best results when running with a high vacuum should give reasonably good performance when exhausting against seven pounds back pressure. Conversely, a turbine designed for opening against seven pounds back pressure would give very indifferent results when run condensing. The case is exactly analagous to that of the compound engine. We can build an efficient condensing engine which is not at all adapted for exhausting against seven pounds back pressure, and we can build a very excellent engine for operating against seven pounds back pressure which would not have a very creditable record when run condensing. We could also build either a turbine or a compound engine of a sort of mongrel type that would be neither very good nor very bad under either extreme condition of operation.

I suspect that this question is prompted by some one who is interested in the problem of utilizing the exhaust steam from a central station, under a considerable back pressure, for steam heating in winter, and still being able in summer to operate condensing with the highest degree of economy. If this be the case, it might be pertinent to add that there is no type of engine, either reciprocating or turbine, that with the advent of the heating season can be easily and quickly altered into an efficient non-condensing machine and as readily put back into its original condition when the summer season is on. It is my belief that the turbine principle can be satisfactorily employed in the design of such an engine, and if the demand were sufficiently great to warrant the necessary development work, and if manufacturers could get a little ahead of the demand for turbines of standard design, there is every probability that such a machine would soon be an accomplished fact.

HENRY E. LONGWELL.

No. 21.—What is the best dressing for leather belts, and what is the proper method of applying it?

We can not say what is the best dressing for belts, but very little of any kind is necessary.

PERRY ELECTRIC LT., HEAT AND POWER CO.

In our opinion, the best dressing for leather belts is a substance that will work into the pores, rendering the belt pliable and impervious to moisture. Most of the belt dressings on the market are simply sticky substances that remain on the outer surface, collect dust and make the belt stiff. In the long run these do the belt greater injury than if it were used without dressing of any kind.

S. S. INGMAN.

Two gallons of castor oil and two gallons of neatsfoot oil, mixed. Run the belts slowly and apply the dressing on the face until thoroughly soaked. Let them dry for about three hours. Keep the back of the belt clean with a brush.

THE SHERBROOKE PR., LT. AND HT. CO.

We have obtained better results from the tanner's oil dressing than from anything we have tried. It keeps the belt soft and pliable when applied warm (at a temperature of 120 to 140 degrees) with a bunch of cloth or waste, well rubbed into the leather. Four treatments annually will be sufficient to keep the belt in good condition if it is located in a dry room where there is little dust.

JAS. E. PYLE.

One part neatsfoot oil and one part mutton tallow. Warm and stir together. Stir one way, as in making starch. After cooling, apply to belt lightly.

FRED. B. SHARPE.

As the only object of a belt dressing should be to soften the leather, neatsfoot oil, or a preparation similar in nature, is unquestionably the best to use, applying a little at a time with a sponge, while the belt is running slowly. Keep all the sticky dressings from leather belts that are in good condition. On old belts, which have lost their natural qualities, it is often necessary, and advisable, to use such a dressing in order to prevent slipping. Don't figure the width of belts too closely ; a dollars' worth of liberality in this direction is anything but extravagance.

CHAS. H. PETERS.

We find that good neatsfoot oil is the best belt dressing one can use. Apply it with a brush at frequent intervals, and only in small quantities; just enough to prevent the belts from becoming hard and cracking.

W. J. TROTT.

No. 22.—How should belts be cleaned, and what will prevent them from slipping ?

The question of cleaning belts depends upon the material of which they are to be cleaned. Should they be caked up with an accumulation of dust and belt dressing, the best way is to scrape them with a thin plate of steel that is sharp enough to remove the dirt but not to cut the leather. If a belt is full of machine oil, it can be scrubbed with a brush in a naphtha bath, which will not injure the belt in any way, and afterward be treated with a tanner's oil dressing This treatment will prevent belts from slipping unless very much overloaded.

JAS. E. PYLE.

Scrape lightly, brush with stiff brush and gasoline, and wipe dry. Keep the belt clean and pliable, and just tight enough, and it will not slip. If the trouble is from the pulley, cover the outside of the pulley with leather.

FRED. B. SHARPE.

Belts that are oil-soaked can be cleansed by rolling up loosely and immersing for 24 hours in a can of naphtha, the can being large enough to receive the roll and provided with a well-fitting lid. When dry, if the belt is a good one, treat with a clear dressing, free from stickiness. CHAS. H. PETERS.

Immerse them in gasoline to take out oil and grease.

FRED. B. HUBBELL.

With belts driving 200 horse-power and less we use paper pulleys on our dynamos and can use the belts slack. Anti-slips have never done much for us.

THE SOUTHAMPTON ELEC. LT. CO.

No. 23.—What is the best method of making temporary repairs to belts of 16 inches or less, when time is an object?

We advocate the use of small steel belt hooks that can be driven into the belt without first making a hole, clinching them on the opposite side. We only use these for temporary repairs that must be made very quickly. As soon as possible, the repair is made permanent by splicing and gluing. These hooks should not be used on wooden-faced pulleys unless they are well driven into the belt; otherwise they will ruin the face of the pulley. We think they are far superior to rivets, and they are more quickly handled than anything else we have tried.

S. S. INGMAN.

The best way in which to make temporary repairs to belts 16 inches in width, or less, is to have the necessary equipment for doing the work and have your all-round mechanic learn to make such repairs by properly joining and cementing the belts when they are out of service. JAS. E. PYLE.

If you have four hours' time, you can cement a belt and make a lasting job; if not, lace it. FRED. B. SHARPE.

No. 24.—Is it good practice to use the water of condensation from a surface condenser for boiler feed? What precautions must be taken to separate the oil from the water and to prevent the water from corroding the boiler?

The water of condensation from surface condensers may be safely used for boiler-feed purposes if a pure mineral cylinder oil is used, without any particular attention being paid to separating the oil from the water, provided it is used in return tubular boilers and the boilers are cleaned at reasonable intervals, say once in two weeks. This cleaning is not difficult, consisting mostly of removing the oil that adheres to the plates at and above the water line and to the tubes throughout the boiler. In the writer's opinion some further precautions are necessary when the water is to be used in water-tube boilers. Oil separators of ample capacity in the exhaust pipe between the engine and condensers will, if properly installed, usually prove effective and will prevent any trouble from oil in the boilers, provided the oil contains no animal or vegetable components. The "make-up" water which it is necessary to supply usually contains sufficient lime or magnesia to prevent corrosion or pitting in the boiler. PEORIA GAS AND ELECTRIC CO.

By using a good quality of cylinder oil that contains no animal oil and by using a good oil extractor, the water of condensation can be used for boiler feed. It is, so far as I know, impossible to remove all of the oil, but a slight trace of purely mineral oil does not seem to injure the boiler in any way.

W. M. CRAIG.

It is good practice to use the water of condensation from a surface condenser for boiler feed, provided oil is taken out of the water before it is used. Thus far there have been very few cases of this being successfully done. W. S. BARSTOW.

This is good practice where the water is muddy or impure. A first-class separator may be used to separate the oil from the exhaust steam, or a gravity system may be used to separate it from the water after condensing. Usually, enough fresh water must be introduced to make up for that lost in the separator and by leaks, to prevent pitting. If the feed water is so pure that this will not suffice, it is hardly necessary to use the water of condensation. C. C. GILES.

Yes, if a good oil separator and filter are used.

W. B. BLOXHAM.

No. 25.—Have compound dynamos any advantages over shunt machines when run by water-power without governor?

Our experience with any machine running from an ungoverned water-wheel would lead us to say without hesitation that a shunt-wound machine would give about as good regulation—probably quite as good—as a compound-wound. Any increase or decrease of load tends to slow up or speed wheel, and a compound winding would aggravate this trouble.

GEO. B. LAUDER.

No; as variable speed will prevent compound dynamos from compounding properly. W. S. BARSTOW.

An over-compounded dynamo should have a distinct advantage over a shunt machine when run on water-power with poor regulation, as any increase in load causing the speed to drop could be compensated for by properly over-compounding. This arrangement with several machines in parallel, if the various wheels driving them will not regulate together, might get you into rather serious difficulties; but if the water-wheels were all tied together mechanically they would probably be all right. THE EDISON ELEC. ILL'G CO. OF BOSTON.

Yes; if run alone. They have a disadvantage if run in parallel. P. T., N. Y. ED. CO.

No. 26.—What is being done with regard to the operation of alternators in parallel direct-connected to gas engines for central-station work? Are there at the present time any successful foreign or American plants of this description in operation? If so, have any of the members information, which they are willing to impart, as to their success or failure?

Some of the companies with which I am connected are running alternators in parallel driven by gas engines by belt. I have investigated the question rather thoroughly and am pretty well satisfied that parallel operation could be successfully secured by direct-connecting by means of a flexible coupling.

HENRY L. DOHERTY.

We find no trouble in running in parallel—only a little stricter attention to regulator boy. **W. B. BLOXHAM.**

No. 27.—Are not the advantages of the parallel operation of alternators in a small station more than offset by the increased care and attention required?

I should say yes to this question. We have a 350-kw and a 500-kw generator, direct-driven. When first installed we ran them in multiple, but we found that the advantage was not worth the trouble and we therefore discontinued it.

F. ELLWOOD SMITH.

We consider the advantages of parallel operation of alternators in a small station impractical, on account of the increased care and attention necessary. **S. S. INGMAN.**

We believe that when it is possible to secure a fairly even drive for alternators it is decidedly better to parallel them than to jerk the load about with every different combination. We run engine-driven and water-wheel-driven alternators together, and could not ask for a better combination. With proper care of governors and with belted machines, it is a simple matter to place your load just where you most wish it.

CHARLES G. BELL.

When the method is understood, there is no more care required in operating alternating machines in parallel than otherwise, and not so much expense, while it has the advantage of better regulation. In many cases it also requires less wire, as you do not have to run a separate circuit for each machine. It has, furthermore, the advantage of flexibility, in more nearly distributing the load economically on the engines. It is also more reliable. For example: suppose you have three machines of 500-light capacity, and the total load has been reduced by 9 p.m. to 1000 lights; No. 1 has 400; No. 2, 300; No. 3, 300. If one should give out, neither one of these would carry the load of the crippled machine, so some one would be in the dark; but you would only have enough to load two machines, and if operating in parallel you would just have an economical load and the service would be perfect. Suppose the same conditions to exist and all machines in good condition; you shut down one as soon as the other one will carry the load, and by so doing save the friction of one unit, also leaving the other operating at the highest efficiency. In case more machines are used, the above facts become of still more importance. Some may object on account of machines in their plant being of different sizes, but this makes only little difference, as it is easy to adjust each machine to take its proportion of the load. Suppose a number of lights to be installed, the machine on that line already loaded, by paralleling each machine, will assist, otherwise a separate line must be run. H. A. HAMPTON.

If the alternators are direct-coupled or each belted to an independent engine, parallel operation makes it possible to get very much more economical engine performance. With parallel operation the load can be shifted and divided evenly, thus requiring less generator capacity for a given load on station.

In most cases of driving alternators from long-line shafting, the latter advantages only would obtain, and under some conditions might not be sufficient to warrant any extra provision being made for parallel operation. In the large majority of properly designed small and medium-sized plants, parallel operation of a limited number of units requires no additional care, and is highly desirable from the standpoint of economy of operation, reliability of service, and investment required in apparatus for a given load on station. P. JUNKERSFELD.

We believe that less care and attention is required by operating alternators in parallel in a station of any size than where generators are run singly; they have got to be watched, and, when load increases, circuits have got to be transferred. With proper engines and generators and switching apparatus, it is just as simple to run alternators in parallel as direct-current machines. There is, of course, a great gain in the service by doing away with the switching of separate feeders.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

With a station properly designed and equipped, much greater economy can be obtained by parallel operation of alternators, both in labor and in coal.

W. F. W., N. Y. ED. CO.

No. 28.—Is there any economy in motor-driving arc machines?

For plants of 200 lights and under, the series-alternating arc system is, in our opinion, cheaper than motor-driven arc machines, and for larger plants it furnishes an alternative worthy of consideration. Special conditions, however, have much to do with this, as with many other matters connected with the lighting business.

THE SHERBROOKE PR., LT. AND HT. CO.

No economy would result from driving arc machines by motors except under extreme conditions. A good line shaft has a higher efficiency than an electric motor, but the average line shaft has a lesser efficiency. Direct belting to a good engine in driving arc machines will generally give a much lower cost than could be secured by motor driving. W. J. BARKER.

Under some conditions, yes; under others, no. Assuming that direct-current series arc lighting is required, then the cost per kw-hour at arc-light switchboard from motor-driven arc machines supplied from large engine-driven units must be enough lower than when driven from small engines, or line shafting, to allow ample margin for interest and depreciation on extra investment required. In general, with long-time contracts stipulating direct-current and with arc load less than 30 to 35 per cent of total load on station, motor-driven arc machines may prove an economical arrangement.

P. JUNKERSFELD.

In a small station where machines are directly driven by engines, without the intervention of countershafts, no advantage is to be derived by driving arc machines by motors. With the introduction of main or countershaft for driving a number of machines, the use of motors for driving individual sets of machines becomes preferable and in many cases more economical, as it is only necessary to operate the proper number of machines required at all times. From the standpoint of insurance of service, the motor-driven sets are the most reliable, inasmuch as an accident to a set interferes with only a small part of the service, while accidents to a main shaft will often result in a serious and expensive shut-down. There is no question that the motor-driven sets entail a higher first cost, but the results obtained more than offset this in the long run, and more can be realized on such an installation than on a belted one if offered for sale.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The efficiency of drive in direct-coupled motor-generator sets, consisting of a motor coupled to an arc machine, is approximately 95 per cent. The efficiency of drive of a belt-driven arc machine, assuming that this is done through a countershaft, will not exceed 85 per cent. The first cost of a motor drive is very much higher than that of a belt drive. The great advantage lies in the great saving of floor space and in the fact that the arc machine can be located in substations at such a point as will give the most economical distribution of conduits and cables. H. G. STOTT.

The efficiency of such a set, comparing the input to the motor with the output of the arc machine, is about 75 per cent. As the efficiency of a first-class arc machine is about 85 per cent, this would indicate a loss of about 12 per cent in motor. The principal advantage of the system is its flexibility, which makes it possible to distribute the load as required among generators used for other purposes as well. The resulting station economy is certainly greater than would be indicated by the mere loss in motor as compared with loss in belting and shafting.

EDITOR.

There is no direct economy except from considerations of value of (*a*) space, (*b*) location of generating station in relation to distributing centre, (*c*) supplying all services from single type of generating apparatus, and so forth.

P. T., N. Y. ED. CO.

No. 29.—What can be done to make high-tension switchboards more accessible for cleaning, repairs, and general maintenance while in constant operation?

Special attention on the part of the switchboard engineer to the following points will perhaps lead to the desired result:

Thorough insulation of all exposed parts carrying current.

Length and number of high-tension conductors reduced to a minimum.

The arrangement of the above with reference to one another.

The use of current and potential transformers for all instruments.

Rheostats mounted at a distance, as in the basement.

Subdivision of the board into sections.

These suggestions apply, of course, only to boards of the ordinary type. PEORIA GAS AND ELECTRIC CO.

Install the switchboard on the double 'bus-bar system, using duplicate switches for all feeders and generators, as by this method it is at all times convenient to have either half of the apparatus on the board dead for cleaning and repairing purposes without any interruption of service. The use of flameproof wire having ample insulation for the pressures to be handled and the covering of all 'bus-bars and exposed live parts, will aid greatly in attaining the desired end. The most important point, however, is the use of a sufficient amount of space on and around the board to allow the proper placing and insulating of all apparatus without crowding.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

All high-tension boards in constant operation should be designed so that a part can be shut down entirely. The manner in which this can be done depends largely on the arrangement of generating units, feeders, circuits or transmission lines. Two of the general schemes might be called the "duplicate 'bus-bar" and "sectional 'bus-bar" arrangement. Ample allowance of space for all switching apparatus and a complete and carefully worked-out design, conforming fully to local requirements and providing for future extension and possible changes, are of prime importance. P. JUNKERSFELD.

Nothing, except careful insulation and plenty of space around the parts. W. S. BARSTOW.

There should be no such thing as a high-tension switchboard. All high-tension apparatus should be in separate brick compartments for each phase, the switchboard containing only low-tension instruments on secondaries of potential and current transformers. H. G. STOTT.

High-tension switchboards should be laid out with plenty of room and greater distances between instruments, switches and terminals; plenty of room should also be allowed between the back of the board and the wall. If this precaution is taken, high-tension boards, as high as 2,000 volts, can be safely handled while alive by using a well-insulated platform to stand upon, taking the precaution to ground the live part to the platform before starting operation. Cleaning high-tension switchboards, accumulation of dust, dirt, etc., can be accomplished by using compressed air. A very good compressor with a motor can be obtained for about $275 that will serve this purpose very well, using a one-sixteenth-inch opening in the nozzle. The air should be compressed at 80 pounds pressure per square inch and then heated by passing it through a hot coil to thoroughly dry the air and insure its being free from moisture. The accumulation of dust or dirt on a high-tension switchboard is a certain cause for leakage current. C. O. POOLE.

So subdivide the board that each section or panel can be disconnected from the rest of the board during period of light load for systematic cleaning and repairs. The amount of cleaning necessary can be greatly decreased by surrounding the conducting and insulating parts of the switchboard with dust-proof inclosures. W. F. W., N. Y. ED. CO.

Remove all possible apparatus from the rear of the board, such as oil switches and rheostats, by mounting the same on the wall or in the basement. Separate 'bus-bars and other wiring as far as possible and leave as much space as possible behind the board. Provide compressed air for cleaning purposes.

J. H. PERKINS.

No. 30.—What success has been met with in the use of voltage regulators, especially on circuits for power as well as lights? Is there one that can be relied upon to take care of speed variations of five per cent?

We operate our power and lights from the same sets of transformers very successfully by using a Tirrell regulator. We recommend it highly. GEO. B. LAUDER.

We have three stations in connection with our plant; two water stations and one steam. We use potential regulators in each of the circuits from the steam station to distribution. We have two light circuits and one power circuit from the steam station, and in each of these circuits we have the high-potential regulators and we find that they give entire satisfaction. The water stations deliver their current to the switchboard of the steam station. These three stations are worked in multiple. We have a 200-kw three-phase alternator in the steam station and another of the same kind and size in one of the water stations, and a 150-kw of the same type in the other water station. One of these water stations is about three miles and the other about three and one-half miles from the steam station. We have no trouble in working these machines in multiple, and with little attention the regulators take care of the light and power circuits with a variation of about four per cent in speed.

(UNSIGNED.)

Some automatic voltage regulators for light and power circuits are in use, and they take care of fluctuations in pressure up to the limit of their transformer capacity, which is about seven per cent above or below the normal working point. They have been in commercial operation a little less than a year, but have demonstrated that, having sufficient generating and regulating capacity, it is practicable with fluctuating motor loads to maintain a nearly constant potential at the particular point on circuit for which the compensator device on regulator is adjusted. These regulators are in service on the four-wire, three-phase overhead system of the Commonwealth Electric Company.

P. JUNKERSFELD.

(*a*) Indifferent success.

(*b*) Yes, if change of speed does not occur in less time than is required for field to meet it.

P. T., N. Y. ED. CO.

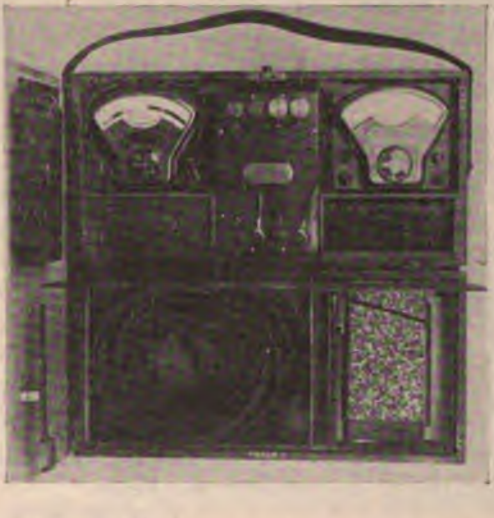
No. 31.—Of what should the testing outfit consist in a small central station supplying direct current for arcs and alternating current for incandescents? What would be the cost?

The testing outfit should consist of a lamp-testing wattmeter, a portable wattmeter, a portable voltmeter, a portable ammeter, a stop-watch and a photometer. The cost not definitely known, but about $250.

A. O. FRETZ.

We think we have a novel arrangement for taking care of and transporting our testing outfit for meters. It consists of a box similar to a dress-suit case, 20 inches long inside, nine and one-half inches wide, and three and one-half inches deep on each side, with a fibre division, hinged, which serves as a deck when testing. The accompanying cut shows the arrangement with the case open, showing the little shelf with hook to attach to meter base, and the magnet-adjusting wrench.

The contents of the case are as follows: One Weston voltmeter; two scales, one reading 0 to 150 and the other reading 0 to 300; one milli-ammeter with shunts, 1.5, 15 and 75 amperes. Adjoining the voltmeter is a small box for carrying the Thomson pocket repair outfit, meter seals, and other sundries; the other small box has a receptacle for the stop-watch, extra plugs, and such sundries as are found necessary in testing and adjusting meters. On the opposite side of the case there is a receptacle for the books and blank paper, a receptacle for the sealing tool and magnet wrench, and a larger space to carry the flexible cables, voltmeter cords, and a small Davidson syringe for cleaning commutators. This outfit, including everything, cost $220.50, and, as equipped, is suited for direct-current work only.



For alternating-current testing we use a Thomson inclined coil, direct-reading portable wattmeter and a Weston alternating voltmeter, which instruments take the place of the direct-current instruments as shown in the carrying case, taking out the direct-current shunt, using the same cables and voltmeter cords. The alternating set cost $97.50.

In connection with the above, we have three banks of test lamps, which are carried with the outfit to make a fixed load on the meter to be tested. E. B. GREENE.

Ammeters, voltmeters and indicating wattmeters of suitable capacities to suit the capacity of the various generators and feeders in the station. The prices of such instruments vary with capacities, and it is suggested that the catalogues of the manufacturers will give this information accurately. Cost should be under $500.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

D. C. and A. C. standard voltmeters
" " " ammeters
" " " wattmeters
Stop-watch
Set of incandescent lamps (standardized for amperes at given volts)
Station photometer
Set of candle-power standard lamps
Magneto and bell
Bridge testing set, for testing out circuits
For highest accuracy station potentiometer with standard cells would also be needed.

The cost of the above outfit will be determined by the extent and quality of instruments purchased.

T. W. V., N. Y. ED. CO.

No. 32.—What is the opinion of the association regarding storage batteries after they have been in operation three or four years, under conditions of moderate use, as compared with the efficiency when first installed?

Replying to your request to answer this question, I would say that the word "efficiency" is used so often in connection with storage batteries where *capacity* is meant, that I feel that what you desire to know is whether or not there is a marked change in capacity after batteries have been in service for some time.

As a matter of fact, there is practically little or no change in *efficiency*. Possibly a little sulphate may accumulate, raising the internal resistance slightly, but the effect of this on the watt efficiency of a battery is practically negligible. The *capacity*, however, decreases with the age and number of discharges of any cell. The capacity of the positive plate decreases slightly, due to the gradual accumulation of sulphate clogging the pores, and to loss of active material. This active material lost is in part replaced by the electro-chemical action in the battery itself, and the positive plate does not begin to lose capacity until after the fourth or fifth discharge. These remarks refer to pasted plates.

Planté positive plates gradually increase in capacity with use, up to the point where the working away of active material from the ribs and exposed surfaces begins to cause a decrease in the available active surface, after which the capacity will decrease.

Negative plates of either type of battery continue to decrease in capacity from the time they are in service, and no reforming action takes place at this electrode. Consequently the negative plates are always made with an excess of capacity over that of the positives (in practice, from 40 to 60 per cent), and it is intended that a set of negative electrodes shall not lose enough capacity to bring them down to the capacity of the positives before the two sets of positives are worn out; by this time, the negative plates themselves have to be renewed. In actual practice, we find that as a battery nears the end of its life its capacity decreases from 10 per cent to 25 per cent less than the capacity when new. Of course, if the use of a battery be sufficiently prolonged, the electrodes will finally disappear and the capacity be reduced to zero. This has no practical bearing, however, and the figures given represent about the decrease that may be expected up to the point where the battery becomes practically useless, unless the plates be renewed.

No rule can be given, because all the conditions upon which this loss of capacity depends are different in each and every plant, and depend on rates of discharge, number of discharges, whether overcharged or "boiled" at proper intervals, density of electrolyte, temperature at which operated, the voltage down to which cells are carried on discharge, and other minor factors.

I trust that this covers the question, and regret that the inherent characteristics of storage batteries are such that definite data can seldom be furnished. LAMAR LYNDON.

A battery that has been installed for three or four years and operated under conditions of moderate use, having from the beginning had careful attendance, should continue to give good satisfaction and its efficiency should be comparatively near to its efficiency at the time of installation. Emphasis must be placed upon the expressions "moderate use" and "careful attendance," for the length of time a battery will do good work depends entirely upon the conditions of operation and upon the care given it. The life of a battery should not be rated in terms of years, for batteries are seldom operated under the same conditions and the results obtained from one may not compare at all with those from another. As a rule, the life of a battery is inversely proportional to the total number of ampere-hours discharged, other conditions being favorable.

The most important factors in determining the length of time which a battery will do good service, are the rates of discharge and charge, the proper amount of charge, the temperature at which the cells are kept, and the care given them, which includes cleaning the cells, watering, and protection from impurities in electrolyte. The most important, perhaps, are the amount of charge and the cleaning. As to the charge, it is absolutely necessary that it be brought up to the right point and then stopped, if good capacity and long life are desired. The time to cut off the charge must be determined after the battery has been in operation a sufficient length of time to adapt itself to the work it has to do. One of the surest ways to shorten the life of the battery is to overcharge it continuously. The work of keeping the battery free from the collection of growth on the plates should be carried on systematically and carefully, and an inspection, with the aid of a lamp, of all cells cleaned should be made as soon after cleaning as possible, to make sure that the work was thorough, for many batteries have been ruined because this very important work was neglected. It may be said, in general, that if the same conditions exist at the end of three or four years that made it necessary to install the battery in the first place, and if care has been used in handling it, while there will have been some plate renewals and some loss in ampere-hour capacity, the efficiency of the battery as auxiliary apparatus will be just as high as at the time of installation.

ERNEST LUNN.

Ordinarily, if a battery has received proper care it should be as efficient at the end of three or four years as when first installed. W. S. BARSTOW.

A special test made of a battery in use over four years shows a watt efficiency and ampere efficiency practically the same as when new. W. I. D., N. Y. ED. CO.

Provided that at the end of three or four years a storage battery has its original capacity and provided the purity of the electrolyte is maintained, there is no reason why a battery receiving proper attention should not have practically the same efficiency as when first installed. If a battery has lost capacity and an attempt is made to restore it by continuous overcharging, the efficiency will suffer some reduction. If impurities are introduced into the electrolyte, such as copper, chlorine, iron, or other metals, in harmful quantity, the result is a loss of efficiency due to local action upon the plates.

Frequently a battery in service three or four years is allowed to accumulate sediment, either at the bottom of the tank enough to reach the plates, or between the plates themselves, causing incipient short-circuits, thereby apparently decreasing the efficiency. W. C. L. EGLIN.

No. 33.—What are the causes of hot bearings, and what are the best cures for same?

Hot bearings are usually caused by want of oil, and sometimes by grit in the oil. The cure is plenty of oil; in fact, the bearings should be flooded if very hot, continuing the flooding until cooled off. Bearings will sometimes get hot from too tight a belt. In this case the remedy is obvious.

S. S. INGMAN.

The cause of hot bearings can be reduced to three in number: First, bearings too small for the work that is put upon them. Second, poor construction. Third, lack of proper lubrication. The second and third are usually the principal causes; the third oftener than either of the others. We have found that in self-oiling bearings provided with rings the oil grooves are often cut in such a manner that the oil can not distribute equally over the bearing surface. The bearings are often allowed to run long enough without proper cleaning to cause the oil grooves to become stopped up, thus preventing the necessary circulation of oil; or the ring may be prevented from rotating by an accumulation of dirt in the oil reservoir. But more often the oil is permitted to get too low in the bearings to allow the rings to carry up a sufficient quantity on to the shaft. In engine bearings the trouble is usually caused by allowing the oil cups to get empty, or by keeping the bearings too tight.

JAS. E. PYLE.

The chief causes of hot bearings are lack of oil, poor alignment, insufficient clearance or clogging of oil grooves, inferior quality of lubricant, or grit. Remedying any of these will usually remove the trouble. If the box is a babbitted one, and the babbitt is not all run out, don't shut down entirely, but turn over slowly, meanwhile cooling off with an ample supply of cylinder oil, oil and white lead, or oil and graphite. If water or ice becomes necessary, use with proper caution, remembering the portion that needs contracting. I recently saw an engine that was wrecked through the ignorance of a man emptying a bucket of water over a badly heated eccentric; the sudden chilling of the strap caused it to shrink. It is unnecessary to give further details. Just because a bearing heats up and you succeed in cooling it somewhat, don't imagine further attention is unnecessary; overhaul thoroughly.

CHAS. H. PETERS.

First—*Lack of oil.* To cure this, wake up the oiler. To do good work, an oiler must be busy enough to be alert, and should be expected to go over all the bearings at regular intervals, whether they run well or not, and to fill same; in case of self-oiling bearings, to look into same and see if rings are turning. He should feel that he holds a position of great responsibility, in which event he will find his work—usually so monotonous—much more interesting. If an oiler is not trustworthy, he is useless. If oil cups are used, be sure that they drip constantly and regularly; if they do not so operate, clean the cups as soon as any sign of trouble is noted.

Second—*Rings not turning in self-oiling bearings.* Many rings will not start when the machinery is first put in operation, and any such rings should have immediate attention and be started by prodding with a stick, which should always be kept in a handy place. If self-oiling rings are not started at once they will soon wear flat and hang on the journals, thereby giving constant trouble. If bearings are hot enough to smoke, use an extra quantity of oil until heat has been reduced, pouring oil directly on the rings, and refill oil well with cool oil several times, being careful to pour oil in over journal while the oil well is being refilled. Apply a rag dipped in cool water to outside bearing. In case of automatic overflow gauge, it is not necessary to empty the oil well, but set a bucket under overflow and pour in cylinder oil in a stream until the bearing is cool; then pour engine oil until cylinder oil is all out and clear oil overflows into the bucket. If the bearing is inclined to run warm, pour in more oil at intervals, and dirty oil as well as cylinder oil will go to the bottom and overflow, leaving the bearing full of clean oil.

Third—*Shafting out of line; oil grooves stopped up; bearings or journals rough; foreign matter in oil well or oil.* Line up the shaft, being careful to take out both top and bottom bearings; recut oil grooves in bearings and carefully scrape and clean same. Clean out the oil well thoroughly and refill with new oil until gauge overflows. In case overflow gauge is used and foreign matter is in oil, clean out the filter.

Fourth—*Worn-out oil.* In self-oiling bearings, the oil, being constantly re-used, becomes worn out. If an overflow gauge is not used the oil should be removed every thirty days. If an overflow gauge is used, a little oil can be added occasionally and the oil in the well will not have to be renewed so frequently; we consider every three months to be good practice.

Fifth—*Inaccessibility of some parts to receive oil.* Among cases of this kind are certain parts of shaft governors. About the only advice we can give is to oil all parts carefully immediately before starting the engine, as a centrifugal motion will hold a great deal of oil that would soon drain off if the engine was not started at once. Another part that has caused considerable trouble is the thrust collar bearings on large shafts. Most manufacturers make the same cap for these bearings as they do for others, with hole inside of ring to pour oil in, but no way to get the oil on to the collar. Such an arrangement causes almost continual trouble. A simple and effective remedy is to bore a hole in the cap and oil through this with a sight-feed oil cup. This practice applies to cases where the collar is in the centre of the bearing.

Put a can under the gauge and the worn-out oil will settle and flow out into the can and can be filtered and renewed.

H. A. HAMPTON.

Hot bearings are usually caused by foreign gritty matter coming in contact with bearing surfaces. This bridges the film of oil lying between the shaft and bearing, and the foreign matter is thus subjected to great pressure. This causes undue friction, owing to the absence of an oil film, also to the small surface exposed to so great a strain. This, in turn, creates heat, resulting in the expansion of the brass or babbitt lining of the bearing, effecting a flattening of the arc of contact of the bearing. This flattening reduces the bearing surface to such an extent that it becomes inadequate to support the shaft with a factor of safety, thus augmenting the friction coefficient and crowding out the film of oil. Without the oil film, the bearing quickly heats up and particles of babbitt are dragged up by the shaft, which augments the heating.

Hot bearings caused by grit or foreign matter are best treated by a liberal flooding of kerosene oil, which washes out the particles. This is followed by a small amount of white lead cut in engine or cylinder oil, which is fed copiously. This, of course, applies to bearings that are not so far gone as to have melted down. Should a bearing become so hot as to drop, it is usually past redemption. In case the machine can be shut down, the best course is to wash out the bearing and scrape it to a clean finish. Cleanliness of machinery and oiling devices are good preventives, and worth more than cures.

GUY C. GUM.

Use graphite. FRED. B. HUBBELL.

Foreign matter in the oil is the general cause. The best cure is to flush it out with water.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Dirt and empty oil cups.

SOUTHAMPTON ELECTRIC LIGHT CO.

Causes—Lack of bearing surface for supporting given weight. Bearing surface made of poor material. Improper fit or adjustment of boxes. Improperly distributed oil ways and tubes. Clogged oil tubes. Unsuitable oil. Dirty oil. Inattention.

Cure—Study each occurrence and apply remedy to remove cause. W. I. D., N. Y. ED. CO.

No. 34.—What is the best method of filtering engine oil?

After oil has been filtered through charcoal filter, I have found that it can be considerably revivified by heating to the boiling point and then covering up and allowing to cool slowly.

GEORGE L. COLGATE.

We have been operating our plant with gas engines and used, until recently, two 110-hp, 2-cylinder Otto gas engines. We had considerable trouble from oil waste, as the drip from the journals and the cylinder oil came out in the bed plate and ran off together. The best method we found for filtering this oil so that it could be used again was first to pour the oil into an oil filter and let it run from this into another oil filter. By this means the oil was filtered so that it could be used on line shaft and engine journals. A. M. JONES.

We use an oil filter that we have made ourselves. It is an iron cylinder, and the oil is filtered through four inches of waste. The oil is carried into this filter automatically from the engines and the filtered oil runs automatically from the filter into a tank, the water also being taken away automatically. The waste is changed frequently, and we have obtained very good results.

F. ELLWOOD SMITH.

The best method of filtering engine oil is to allow it to pass through canvas bags, which can be readily cleaned, and then to pass through a settling tank with baffle plates at a very low velocity. H. G. STOTT.

In my opinion the best oil filter is one in which the oil to be filtered is fed through a pipe that delivers it to the bottom of the tank and causes it to pass up through the filtering material to get to the top of the water. There should also be a steam pipe run through the filter, which should enter at or near the bottom and, passing up, leave the filter from the side opposite where it entered. This is to keep the oil warm, as the dirt then separates from it more freely. Near the top of this filter should be placed a gauge glass, also a faucet for removing the oil. The filtering material may be almost anything of a more or less porous nature that will intercept and catch the dirt but still allow the oil to pass through. Hay, excelsior, cotton waste, charcoal, sawdust, sponges and cotton batting, are among the materials used, each of which has its supporters, and each seems to give satisfaction. E. T. WALSH.

The best method might be hard to determine. Whatever system is used, a large settling tank, which will allow the oil time to stand for some days, will be of great assistance in the work. The dirty oil should be introduced near the bottom of the tank and the oil from the top be taken for use. When the dirty oil is introduced at the top, as in some, it keeps the whole amount of oil in a dirty condition. E. W. FURBUSH.

We use a filter which consists of excelsior, felt and cotton waste.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Satisfactory results will be obtained with any of the ordinary filters on the market, provided attention is paid to the following points:

1. The filtering material should be frequently cleansed and changed.
2. The oil should be kept at a temperature of 100 degrees Fahrenheit, so that it will have a thoroughly fluid consistency and will allow the dirt and other foreign matter to settle.
3. The filter should not be forced beyond its rating.

W. I. D., N. Y. ED. CO.

In my experience I have found that the best results were obtained by filtering the oil through sand. In constructing such an oil filter it should be made of galvanized iron, having two tanks, one to fit into and above the other. In the bottom of the upper tank place about six inches of best white waste, and on top of this place twelve inches of clean white sand, as fine as possible. This upper tank has a quarter-inch pipe connected at the bottom and running to within an inch of the bottom of the lower tank, where it is fitted with a short return bend. Fill the lower tank two-thirds full of water, at which point place a small faucet for drawing off the filtered oil. The object of the water is to wash the oil.

The above tank, made 18 inches in diameter, the upper being 24 inches high and the lower 26 inches high, will filter from three to five gallons of oil in 24 hours and will last for about two years without renewing the oil and waste.

F. M. FRIEDBERG.

No. 35.—What kind of oil has been found most suitable for high-speed dynamos with brass bearings?

We have tried various makes and grades of oil for our high-speed engines and dynamos with brass bearings, and we get the best results from a medium-light engine oil if fed through a cup, and a little lighter for the self-oiling (ring) bearings. We have a dynamo with brass bearings (ring-oiling) that has run two years, and the last 12 months with but one filling of red engine oil.

S. S. INGMAN.

A pure mineral oil of light body.

W. I. D., N. Y. ED. CO.

No. 36.—Will some one describe a good, cheap blower set for cleaning dynamos and give approximate cost?

We are using a second-hand, six-inch Westinghouse air pump, which we purchased from a steam railway company. The cost of the pump, tank, pipe and hose was $180.

F. ELLWOOD SMITH.

We use a Westinghouse air pump, connected to a tank 24 inches in diameter, 41 inches long. The object of the tank is a reservoir for compressed air, and it takes care of the condensation in the compressed air. The air pump has an automatic pressure-reducing valve in the steam connection, which shuts off the steam at any determined air pressure (we use 40 pounds). From this tank we pipe to several outlets near to dynamos and to our workshop, and use a piece of hose with nozzle. We find this a very economical method for cleaning dynamos and arc lamps, and for such other work as comes to the repair shop. The cost of this pump and air tank is $125.

E. B. GREENE.

We have used a Westinghouse air-brake pump bought second-hand from the railroad people and equipped with a tank. This

outfit ought not to cost more than $200 or $300. We also have in use a direct-connected motor-driven air compressor. This is a somewhat larger machine, driven by a 4-hp motor and equipped with a tank to maintain 50 pounds pressure on half-inch opening. This would probably cost $600 or $700. For cleaning purposes the air-brake pump is perfectly satisfactory.
THE EDISON ELEC. ILL'G CO. OF BOSTON.

A good, cheap blower set for cleaning dynamos can be made by procuring a small steam blower and connecting it to a short piece of eight-inch or ten-inch steam pipe, capped on each end to form a holder. Pipes can be run from this to any part of the power-house from which taps can be taken for hose connections. With a short piece of hose about three-fourths of an inch in diameter, with a one-eighth or three-sixteenths-inch nozzle, the equipment is complete. The whole outfit can be built for about $60 for a small plant. JAS. E. PYLE.

We have just installed in our plant a blower outfit consisting of a Westinghouse air pump, such as is used on locomotives, with steam and air cylinders nine inches in diameter by eight inches stroke. This pumps into a tank 12 inches in diameter, five feet high, tested to 250 pounds per square inch, which is fitted with safety valve and pressure gauge. The pipe system runs from this tank to pockets near dynamos, in which are valves and threaded hose connections. Twenty-five feet of four-ply rubber hose—three-quarters-inch—provided with a nozzle, enables us to get all around dynamos or at any point on switchboards. A branch of the pipe line runs into workshops for cleaning arc lamps, meters, etc., the pressure being adjusted to requirements. As we purchased the air pump, which is practically new, at a bargain, the whole system did not cost in excess of $175. We would not be without it for twice that sum, as compressed air can be used for many other purposes in a power-house. CHAS. H. PETERS.

We have recently installed in our substations a small, one-hp, series, 500-volt, direct-connected blowing outfit, built by the Christensen Engineering Company, of Milwaukee, Wis. The motor and pump, together with the air tank, indicator and controlling devices, are all mounted on a small truck, so that the outfit may be used in any part of the station or substations by having different points of attachment for current and a long supply cord. A flexible joint was provided for the aïr hose. The approximate cost of these outfits was $275 each.

THE YOUNGSTOWN CONSOL. GAS AND ELEC. CO.

No. 37.—How do you calculate the size of pipe required for exhaust steam heating at, say, five pounds back pressure?

I should use the formula given on page 671 of my *Mechanical Engineers' Pocket-Book*, viz.: $W = c\sqrt{\frac{w\,(p_1 - p_2)\,d_5}{L}}$, in which W = weight of steam flowing, in pounds per minute; *c*, a constant which may be taken at from 52 for a two-inch up to 60 for an eight-inch pipe (it is generally taken at 60 for all sizes for approximate calculations, and the error in so doing is small, since the small sizes of pipe have an actual diameter larger than the nominal diameter); *w*, the weight in pounds of one cubic foot of steam of the pressure at the entrance of the pipe; p_1, the initial and p_2 the final pressure; $p_1 - p_2$ = drop in pressure in pounds per square inch; L = length of pipe in feet, and *d* its diameter in inches.

We first have to assume the drop in pressure that may be allowed. In most cases this can be taken at two pounds in 1000 feet, or $\frac{p_1 - p_2}{L} = .002.$

We then have to assume the initial pressure, p_1 which will vary according to the resistance of the several branch pipes, headers, elbows, water-binds, etc., in the heating system, and according to whether there is a vacuum system for reducing the pressure in the returns. It will vary from atmospheric pressure to upwards of 10 pounds in some large and improperly-piped systems. From this value of p_1 we take the value of *w* from a steam table, viz.:

p_1 (above atmosphere) 0, 0.3, 1.3, 2.3, 3.3, 4.3, 5.3, 6.3
W, pounds per cubic foot, .038, .039, .041 .044, .046, .051, .053

Taking *c* at 60, $\frac{p_1 - p_2}{L} = .002$ and $w = .051$. the formula reduces to $W = 60\sqrt{.051 \times .002 \times d^5} = 0.6\sqrt{d^5}$

From tables of fifth powers and square roots we take values of $\sqrt{d^5}$

$d =$	2	3	4	5	6	8	10	12
$d^5 =$	32	343	1024	3125	7776	32,768	100,000	248,332
$\sqrt{d^5} =$	5.66	18.5	32	55.9	88.2	181	316	499

We then find that the value of $W = 0.6 \sqrt{d^5}$

$W = 3.4 \quad 11.1 \quad 19.2 \quad 33.4 \quad 52.9 \quad 108.6 \quad 189.6 \quad 298.4$

For any other value of p than 5.3 pounds, the flow will vary as the square root of the corresponding value of W. Thus, for $p = 1.3$ pounds, $w = .041$, the values of w found as above will have to be multiplied by $\sqrt{\frac{.041}{.051}} = \sqrt{.08}$, or 0.894.

For any other drop than two pounds per 1000 feet the flow will vary as the square root of the drop; thus, for a drop of one pound per 1000 feet the obtained values will have to be multiplied by $\sqrt{1/2} = .707$.

Example: How much steam of an initial pressure of 1.3 pounds above atmosphere will flow per minute in a six-inch pipe with a drop in pressure at the rate of one pound per 1000 feet?

Answer: $52.9 \times 0.894 \times 0.707 = 33.4$ pounds.

If the quantity of steam is stated in boiler horse-power, we multiply the values of w by a factor representing the ratio of one pound of steam per minute to 34.5 pounds per hour, or one horse-power, viz., $\frac{60}{34.5} = 1.74$.

A six-inch pipe with five pounds back pressure and two pounds drop per 1000 feet would carry $52.9 \times 1.74 = 92.0$ horse-power.

WILLIAM KENT.

The size of a pipe supplied with exhaust steam under five pounds pressure and used to supply radiators for heating a building, may be determined by the following formula taken from the top of page 51 of Professor Carpenter's book on ***Heating and Ventilating Buildings:***

$$d = 0.184 \sqrt[5]{\frac{w^2 l}{p \delta}}$$

where d = diameter in inches

w = weight of steam discharged per minute

l = length of pipe in feet

δ = density of weight of a cubic foot of the steam.

The rule suggested by the late George H. Babcock and adopted by William J. Baldwin in his book on *Steam Heating for Buildings*, is

"The diameter of the main supplying the radiating surface should be equal in inches to one-tenth of the square root of the radiating surface, mains included, in square feet." This is no doubt the most convenient rule to apply.

Any book on the heating or ventilation of buildings will contain formulæ and rules relating to this topic. They are all empirical, and are to be used only under the conditions of the tests from which they were deduced. Length of main, number of bends, character of the heating system—whether gravity or vacuum—and other considerations, must be known, as well as extent of heating surface in coils, character of building construction and exposure of building, before the size of exhaust feeder main can be definitely determined. (UNSIGNED.)

No. 38.—What is the best pressure-reducing valve for use in connection with heating system where it is occasionally desirable to use live steam?

The Mason reducing valve is very reliable, and has been adopted by the American District Steam Co. on our recommendation. They have used it several years.

C. P. WELLES.

We know of no pressure-reducing valve that is particularly satisfactory.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Of the pressure-reducing valves, our experience has been that one of the types of diaphragm valve and one of the types of piston-controlled valve are the most satisfactory of any that we have used. Good results from reducing valves are obtained only by proper application of the valve to suit individual conditions. The principal point to be provided for is in using the smallest valve that will pass the required volume of steam ; the reason for this being that a small valve run wide open under normal conditions avoids cutting of seats from wire-drawing, where a larger valve run partially open would soon be rendered worthless. J. P. S., N. Y. ED. CO.

No. 39.—Will some one give details of a machine shop suitable for a station of 1000-hp to 1500-hp capacity; stating what tools and what machine tools should be included, and what the cost would be?

We have a small shop that meets our requirements very well., It is equipped with a 2-hp motor with variable-speed rheostat, one Barnes screw-cutting lathe, five-foot bed with a 10-inch universal jaw chuck, together with the usual tools for turning and threading as furnished with the lathe. The lathe has a swing, as received, of 13 inches; a set of raising blocks was added to this equipment, giving it a swing of 18 inches.

A drill press with a swing of 26 inches, movable table and a square, accurately planed base, together with the usual complement of drills, and a set of rose reamers up to two inches in diameter, suitable in sizes for repairs to engine governors.

An emery wheel suitable for general work.

The cost was as follows:

Lathe, including the tools and chuck	$149.50
Drill press	65.00
Chuck for holding small drills	4.50
Drills and rose reamers	30.00
Emery wheel and frame	30.00
Total	$279.00

With the above-named tools, in the past 10 years we have gone outside our shop for only four pieces of work, which work was of too large diameter for our lathe. The occasion for having to do large work occurs so seldom that it would not warrant the expense of a lathe large enough to swing everything.

E. B. GREENE.

Regarding equipment of machine shop suitable for a station of from 1000 to 1500 horse-power, the selection of tools for handling repairs would be governed to a great extent by size of unit. A good equipment for a station consisting of units of from 250 to 500 horse-power would be a 12-inch to 16-inch screw lathe of 10-foot bed, one 24-inch to 28-inch lathe of 15-foot bed, one 20-inch shaper, one 20-inch to 30-inch drill press, one 12-inch to 15-inch sensitive drill, and one emery grinder running 12-inch to 14-inch wheels. The small tools required in a plant of this size should consist of pipe dies cutting from one-eighth inch to three inches, with pipe taps of the same sizes; small tools for lathes, shaper and drill press as required. The cost of such an outfit as this, if driven by one motor with necessary countershaft, should be about $200 installed, exclusive of motor. If direct-driven machine tools are selected, the cost should be about $3,000 for the entire outfit.

J. P. S., N. Y. ED. CO.

No 40.—What is the comparative value of towels and waste for cleaning purposes? How often can towels be cleaned and used again?

We have found that towels will rot in a short time if used to wipe up grease, etc. FRED. B. HUBBELL.

There is no difference as to gross cost. Towels are much more effective. GEO. L. COLGATE.

We formerly used waste, and use a little now, but most of our wiping is done with cotton cloths. These are not regular wiping towels, but are remnants of cotton cloth, which we buy by the bale. The cloths are washed from time to time, and we think they are a great deal better and cheaper than waste. We wash them until they are worn out.

F. ELLWOOD SMITH.

I should say about 40 cents on the dollar in favor of cotton rags or towels. The lasting qualities vary directly with the character of machinery wiped, as well as the mode of cleansing the towels. By using the squeezing or roller process, instead of lye or strong alkalies, the life of the towel can be prolonged four or five months. GUY C. GUM.

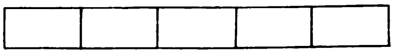
Towels, we believe, cost 90 per cent of what waste would cost. We do not know how often towels can be cleaned and used. THE EDISON ELEC. ILL'G CO. OF BOSTON.

Net expense of wipers is about 25 per cent greater than with waste, even if towels are washed until worn out.

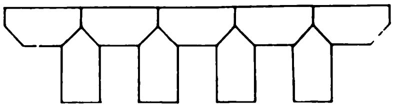
W. I. D., N. Y. ED. CO.

No. 41.—What is the best way in which to lay up fire-brick lining in boiler walls so that it will stay?

You can make fire-brick lining stay in boiler walls by laying every other course a header course. It will, however, be impossible to make equally as good a job when the time comes to repair it on the fire line, necessitated by the partial burning away of the brick at that point. Your headers, not being protected, will burn away also, which will compel you to lay up the new lining without headers. By using a protected header (as per cut) every other course for six or eight courses, or to above fire line and then through header courses every other course, you will get a wall that will stay and one that will be easily and substantially repaired on the fire line.



First, Third and Fifth Courses



Second, Fourth and Sixth Courses

L. W. BYERS.

I have obtained the best results by laying fire-brick all "headers," with a very thin coating of sloppy fire-clay as a cement. This coating is given by immersing the brick in thin fire-clay mixture. Leave a two-inch air space between wall and lining, beginning about ten inches above grate bars and gradually battering into wall at or near the fire line.

GUY C. GUM.

We have obtained very good results by making every other course a header. Have also tried "racking back" from the grate bars up four or five courses, and found it very beneficial, especially where wood is used for fuel. **S. S. INGMAN.**

I lay up about five courses of headers above grates, and from there up use headers and stretchers alternately. An arch from near the grates in front of the bridge-wall in side walls is a good construction. **W. B. BLOXHAM.**

We lay up our side walls with three courses of brick and then a row of headers, laying them up in fire-clay, and have had no difficulty.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

With the same material, best results will be secured in laying of brick by using minimum amount of fire-clay mortar. Pure fire-clay brick should be used without the addition of any grog or fire-sand, and the bricks should be laid as close together as possible, rubbing one brick on top of the other to thin the joints and bring the bricks so they will have a bearing on each other. H. S. RUSSELL.

We use mixture of clay suitable for building brick, anthracite screenings and wood ashes.
THE SOUTHAMPTON ELEC. LT. CO.

No. 42.—Would there be any economy in using an internally-fired boiler instead of an ordinary flue boiler, where the load varies widely, but is always under the capacity of the boiler? Feed water is bad and price of coal high.

We can see no additional economy.
THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 43.—What is the best method of preventing smoke, using an ordinary hand-fired furnace and horizontal multitubular boiler?

The so-called method of "coking" fires will kill the smoke where the boilers are not crowded. E. W. FURBUSH.

Fire light, and only half the furnace, or close the damper every time the furnace door is open, if you can get a man to do it. W. B. BLOXHAM.

No. 44.—How many members of the association have been prosecuted on account of smoke from power-house stack?

No. 45.—How many have succeeded in reducing smoke so that it is not objectionable, and by what means?

It is impossible to eliminate smoke entirely, but it will be reduced to a minimum and found unobjectionable by using a good draft, good quality of coal, and coking on the hearth.
L. W. BYERS.

Stokers and down-draft furnaces will reduce the smoke to a certain extent. W. B. BLOXHAM.

We are using chain-grate stokers, and the smoke is not objectionable.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 46.—What kind of stokers or furnaces have been successfully used in reducing smoke?

Automatic stokers can be successfully used for reducing smoke.
H. G. STOTT.

No. 47.—What are the practical difficulties, if any, in using highly superheated steam as compared with commercially dry steam?

The greatest difficulty in the way of using highly superheated steam is the lubrication of valves. One hundred and sixty degrees of superheat can probably be used.

H. G. STOTT.

No. 48.—What is the steam consumption of steam turbines of large capacity using superheated steam and running condensing, as compared with compound-condensing steam engines under the same conditions?

The best actual result on 100-kw steam turbine, using superheated steam, running condensing, is 19 pounds per kw-hour. The best result published—Suzer triple-expansion condensing engine—is equivalent to 13.2 pounds per kw-hour.

H. G. STOTT.

No. 49.—Under what conditions has it been found advisable to use auxiliary mechanical draft at the time of peak?

Only in case of insufficient draft.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Auxiliary mechanical draft is desirable when the peak-load period is short, and the peak is high in comparison with the average load; or when, for any reason, the total boiler capacity is small in proportion to the load it is occasionally necessary to carry.
EDITOR.

I know of no installation where a mechanical draft was used at time of peak and natural draft was used at other times. It may be interesting to note that in some recent calculations for a big power plant it apparently was cheaper to use mechanical draft until the plant should reach a capacity of 12,000 horse-power, and after that the maintenance of a mechanical draft equipment, the interest and depreciation on same, together with the cost of operation, would amount to more than to build a first-class stack, and thus provide natural draft.

H. R. WEBER.

No. 50.—Which would be the more economical to use in a plant where the load averages 150 horse-power for four hours and 40 to 50 horse-power for eight hours; a simple Corliss engine or a tandem compound, high-speed, non-condensing engine? Coal costs $5.50 per ton and boiler pressure is 140 pounds.

Corliss engine, and use 90 pounds steam with light loads.

GEORGE L. COLGATE.

Tandem compound engine would be most economical. Boiler pressure should be reduced with reduced loads.

H. G. STOTT.

I should say a simple Corliss. W. B. BLOXHAM.

We consider the use of the simple Corliss engine, and keeping the boiler pressure at a point that will give the most economical point of cut-off in the varying loads, as being much the most efficient. G. B. LELAND.

No. 51.—What is the most economical type of engine for an electric-light station using less than 200 horse-power, engine to operate during the dark hours only, running non-condensing, and driving both arc and incandescent machines by means of a belt? Price of Illinois soft coal is $1.80 per short ton; water is obtained from well.

Automatic, high-speed, simple engine, because of low first cost, good regulation, and small space required.

BRUSH-SWAN ELEC. LT. CO.

If 150 horse-power, compound Corliss.

GEORGE L. COLGATE.

Conditions have all to do with deciding such a question. If these are the same as the average, in which, beginning with first hour or so, the load gradually increases until the maximum is reached during the next hour, continuing for two hours and then rapidly falling off until the minimum—which should be about one-third maximum load—for the rest of the night, say, six hours out of the ten—the best results are obtained by having two engines; one for the heavy load and one for the light load. But as other things besides fuel economy are of equal or more importance—such as cost of installation, repairs, attendance, etc.—our experience leads us to conclude that the Corliss or automatic cut-off engine, of ample capacity, will be the most economical to install, all things considered.

S. S. INGMAN.

I should favor a high-speed automatic.

GUY C. GUM.

No. 52.—Is it likely that the gas engine with producer-gas plant will become more economical from all standpoints for central-station use than the steam engine is now or is likely to be within five years to come?

I think it is certain that gas engines for producer gas will be more economical in operating expenses than the steam engine is likely to be within the next five years. The total expense, *viz.*, operating expenses plus fixed charges, will depend upon how much current is produced with a given engine capacity, and as a gas engine costs more than a steam engine, fixed charges will be more per horse-power.

HENRY L. DOHERTY.

No. 53.—Is there a crude petroleum or kerosene engine of 100 to 150 horse-power that can be used as an auxiliary in a small water-power plant without requiring the services of an expert engineer to run it? What would be the consumption of fuel per hp-hour?

No. 54.—For a town of 3000 population and moderate growth, having about 1700 incandescent lamps now installed and city contract for twenty 1200-cp arcs—considering first cost and operating expenses—what is the most economical and serviceable equipment for light and motor service?

Sixty-cycle, single-phase alternating arcs for street lighting in multiple.

GEORGE L. COLGATE.

We should favor 220-volt direct-current apparatus for an installation of this kind if the station can be centrally located and the distance covered does not exceed 2000 feet.

S. S. INGMAN.

Monocyclic system.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The installation of a monocyclic generator and the "tub" system of arc lighting would be the best under conditions given.

G. B. LELAND.

No. 55.—What would be a good showing as to cost per kw-hour on a total output of 550 kw-hours at switchboard; plant running non-condensing from dusk to dawn, and using two tandem compound engines, belted to 75-kw and 45-kw alternators, respectively; coal, one part bituminous and three parts anthracite and costing $3.00 per ton?

Three cents per kw-hour would be a fair showing under the conditions given.

EDITOR.

Three and one-quarter cents per kw-hour.

(UNSIGNED.)

Between six and seven cents.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 56.—Is it practical to operate in multiple two direct-current, compound-wound dynamos of different makes and 50-per-cent difference in size?

Yes; the Rochester Railway Co., Rochester, N. Y., are running one 500-kw Siemens & Halske and one General Electric, 1050 kilowatts, in parallel with perfect success.

BRUSH-SWAN ELEC. LT. CO.

It is possible to operate successfully under the conditions mentioned if the variations in load are not too great and too sudden. To get the best results, you should test each machine separately at various loads on a water rheostat, in order to determine its compounding curve. By shunting the series coil of the machine whose voltage tends to rise most with increase in load, and by varying the resistance of the leads to the 'bus-bars, you will be able to obtain a sufficient approach to uniformity of compounding to enable machines to divide the load automatically under any reasonable variations of station output.

EDITOR.

I have operated direct-current compound-wound generators in multiple of *more* than 50-per-cent difference in size, and consider the same entirely practicable if they are properly connected and have their shunts properly adjusted.

G. B. LELAND.

At the University of Minnesota, we are operating daily under exactly the conditions noted, namely, a generator of one make in multiple with one twice as large from another maker. The two machines are in different buildings, about 800 feet apart, and feed into the same lines. At first, the larger machine grabbed the load. After adjusting the compounding, the two work without difficulty at all conditions of load.

GEO. D. SHEPARDSON.

No. 57.—With three generators running in parallel at full load, one phase of one of the generators short-circuits and goes out of business. Which would be the better practice: To hold on to everything and lower voltage of the remaining machines until after the peak is passed, or to cut off part of the system and keep remainder up to full candle-power?

By all means cut out part of the system and keep the balance up to standard. Cut out the least important portion. The public are reasonable in most cases of accident. Those not affected will not know of the accident, and no loss from poor regulation, etc., will be inflicted on the company.

BRUSH-SWAN ELEC. LT. CO.

Cut off part of load; plant is then disgraced only by breakdown, not by poor quality. GEORGE L. COLGATE.

Hold on to everything.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

My answer to this question would be to run whatever lights are run at proper voltage. A plant cramped for equipment last fall tried the experiment of running under voltage. Instead of lessening their load it increased it, as consumers would turn on additional lights to compensate for the lesser light obtained from operating the usual number of lights in their stores and residences. ANONYMOUS.

No. 58.—With two generators running in parallel, excited by separate units, one exciter breaks down unknown to dynamo tender. What happens to the generator with the broken-down exciter? What method is there of protecting a generator under such circumstances?

Circuit-breakers for both no load and overload in exciter circuit, and for overload in generator circuit.

GEORGE L. COLGATE.

Generator without exciting current would still continue to supply power. Fields would be magnetized by induction from the lagging current received from the other generator. Generator will probably show just about full-load current, no matter what the load may be, part of this being idle current from the other machine and part of it working current. Machine may be protected very effectively by reverse-current relays.

H. G. STOTT.

We do not see how this could remain unknown to the dynamo tender very long. The generator with broken-down exciter would go out of step and practically shut down the station. A reverse-current circuit-breaker would protect a generator under such circumstances.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 59—What has been the experience with automatic regulators whose operation tends to regulate machine voltage?

We operate a static substation in the village of Clyde, eight miles away. The load varies from 0 to 70 amperes, at 1100 volts in station at Lyons. Our loss at 70 amperes is 17 per cent. In order to maintain a constant voltage in the substation at Clyde, it required the constant attention of a man to regulate machines according to load and to keep the voltage according to the chart as laid out by the writer. We at last installed a voltage regulator manufactured by a prominent company, and since then our regulation has been almost perfect. This regulator also compensates for inductive load. We operate 50 alternating-current series inclosed-arc lamps off this line. After it is once thrown into line it needs no attention whatever, and it does the work perfectly. We generate current at 1100 volts, step up to 6600 volts, transmit to Clyde, and step down to 2200.

C. J. SULLIVAN.

We have two automatic voltage regulators connected to our Edison three-wire system. They have been in operation about five years with good success. These regulators are so connected as to be thrown on any machine of the direct-current system, all machines running in parallel. We generally throw them on the two machines carrying the heaviest load. They are very sensitive and quick in action, and take good care of any variation in voltage that may be caused by motors or sudden throwing on of a large number of lights, thus giving us far better regulation than by hand and saving the expense of switchboard attendant. I would recommend them to all central stations.

AUG. WEIS.

No. 60.—What advantages are obtained from the use of step-up, three-phase transformers with Y-connected secondaries and grounded neutral, over the delta-connected transformers; the secondaries of transformers working in multiple with generators developing the same pressure as the secondary of transformers, the neutral point of the generators being grounded?

Reduced pressure on the transformer terminals and lines.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 61.—Are manufacturers making any efforts to produce rectifiers to enable direct-current inclosed-arc lamps to be operated from alternating current machines?

So far as I know, manufacturers are making no special efforts to produce rectifiers to enable direct-current inclosed-arc lamps to be operated from alternating-current machines. The series alternating arc-lamp systems have been brought to such a state of perfection in this country that the question of operating arcs from rectified currents seems to have been relegated to the background. In England, where the first Ferranti rectifiers were installed six or seven years ago, little progress has been made in the development of the system. During the current year Mr. A. H. Preece submitted a report to the borough council of Hammersmith, England, in which he called attention to the fact that on account of the "flashing-over" of the rectifiers, the cable insulation must stand at least 100 per cent above the working pressure. He stated that although the lighting from alternating-current arcs is fairly satisfactory it is by no means so good as the rectified-current lighting. Still he does not recommend the extension of the rectifier system.

There has recently been some activity in the United States in the development of rectifiers (witness the Cooper-Hewitt static converter, the Thomson rectifier, and others), but whether or not these inventions will find an application in the transformation of alternating into direct current for arc-lighting purposes remains to be seen. LOUIS B. MARKS.

Not in this country.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 62.—What is the best and easiest method of removing sediment from storage-battery jars?

By hose syphon, acid-proof.

BRUSH-SWAN ELEC. LT. CO.

We remove enough plates so that we can get into the cell with a scoop after the exide has been scraped off. We understand that a plan has been tried of putting a lead pad near the bottom of the cell so that the sediment can be scraped out without removing the plates.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The most suitable method for removing sediment from a battery varies with the size of the jars or tanks, the location of the battery-room, and the conditions under which the battery is to be cleaned; that is, whether the cleaning is independent of plate renewals or in connection therewith. For the smaller or medium-sized batteries, set up either in glass jars or lead-lined wooden tanks, if the cleaning is to be done independently of plate renewals, the most economical method is to get the sediment out with the least possible disturbance of the plates. This can be accomplished either by the use of a wooden scoop or a rake of such design that it can be inserted at the ends of the tanks and the blade passed under the plates, the sediment being removed as the scoop is withdrawn. The advantages of this method are that it requires a minimum amount of apparatus and labor and avoids the necessity for taking the battery off the system. For the batteries of the larger sizes, either the syphoning or the pumping method is usually most satisfactory. If the room be favorably located, the syphoning method will generally be found the most economical. This involves the drawing-off of the electrolyte of each cell or a group of cells in rotation into tanks or carboys, the filling of the cells with water, an agitation or loosening-up of the sediment, either with a strong stream of water issuing from a nozzle inserted into the cell with an L-bend in the hose, or with an L-shaped piece of rubber-covered stiff metal, and the drawing-off of the sediment-laden water into settling tanks located at a lower level; the water of course being withdrawn when all the sediment is removed and the cells refilled with the acid that was drawn off, the deficiency—due to removing of sediment—being made up by the addition of new acid. In cases where syphoning is not practical, a power pump is substituted for the syphon, one of the advantages of this method being that it is not necessary to substitute the water for the acid in the cells, thus avoiding the necessity for taking the battery off the system while the work is in progress.

In batteries of the largest sizes, as a general rule, the best method is to remove about one-half the plates, when the sediment can be easily gotten at and removed; this involves the reburning of the plates, but this expense is offset by the thorough manner in which the cleaning can be accomplished and also the lessened expenditure of time. If plate renewals are required at the same time that a cleaning is necessary, the sediment can be removed when the old plates are taken out and before the new ones are installed. W. C. L. EGLIN.

No. 63.—Have any members had trouble through the breaking of glass battery jars at the time of, or soon after, removing the sediment from such jars when a wooden scoop is used? Is there any way to prevent such an occurrence?

The breaking of jars under the conditions mentioned in the question is frequently occasioned by rough handling of the jars or of the scoop used for cleaning, or in allowing sloppage of the acid and sediment so that they run down on the outside of the jar, dampening or washing out some of the sand in the supporting trays, causing the sand to shift and putting unequal strains on the jars. When glass-jar batteries are cleaned in extremely cold weather, the breakage is apt to increase, as the jars are naturally very susceptible to the shock in low temperature.

W. C. L. EGLIN.

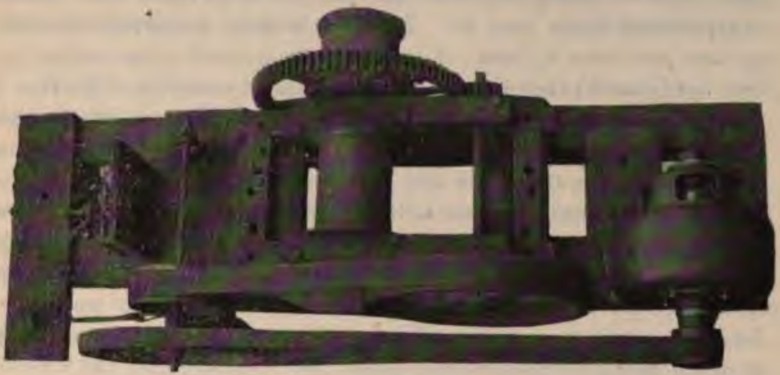
We have had the exact trouble indicated in this question, and have thus far found no way to prevent same. This seems to be a disturbance either of the position of the cell or in the strain on different parts of the jar.

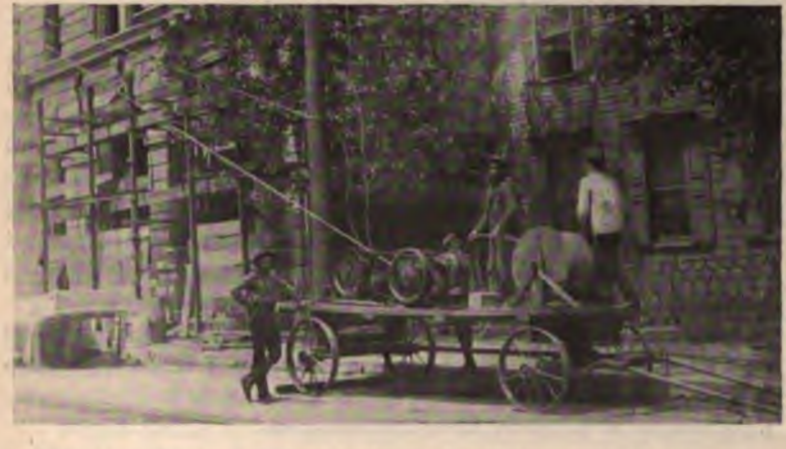
THE YOUNGSTOWN CONSOL. GAS AND ELEC. CO.

No. 64.—What methods have been used to provide fairly uniform temperature and proper ventilation for storage battery of given capacity, and how often is there a complete change of air?

In providing for a fairly uniform temperature and at the same time proper ventilation, it is not generally necessary to install artificial means of heating to keep up the temperature during the colder periods of the year, especially where the ventilating inlets bring air from places where the temperature is normal, such as switchboard or generator rooms; however, the inlet ducts should be so arranged that during the warmer months air from a cooler source than that from the generator or switchboard-room can be obtained. When necessary to raise the battery-room temperature during cold weather and the above arrangement is not practical, then the room may be heated by steam, hot-water coils, or by electric heaters.

In the great majority of cases natural ventilation, obtain by inlets at the floor level at one end of the room and outlets at the ceiling at the other, will be all that is required, but in particular cases, as in very long, low-ceilinged rooms, forced ventilation may be found necessary. To provide for this, a small fan can be installed at the inlet to force air into the room or at the outlet to draw it off. For inlet fans, direct-connected outfits are preferable, but for exhaust fans a belt-driven set will be found most suitable, the belt being of rubber and the fan blades thoroughly protected with a coating that will reasonably resist the action of the acid fumes. The inlet should always be at the end of the room where the regulating cells are installed, so that the fume-laden air will be carried away from the end-cell copper, one inch or ten feet, as you please. It will put 1500 feet of 400,000-circular-mils copper cable up on a pole line when the rope is in place, in 40 minutes; it will draw the cable, with block and falls just as you want, and hold it there until tied in.





The accompanying cut will show how it is secured to a wagon for transportation, the wagon being fastened to a pole with a chain. E. B. GREENE.

Use rope blocks and gin poles, pulling either by windlass or by horse-power, using guys on pole to keep it in line. We have an old horse that will walk up with the largest poles we have to handle, as regúlarly as clockwork.

THE SHERBROOKE PR., LT. AND HT. CO.

There is no specific way which I could claim as the cheapest or best for erecting large poles. The cost of the erection of a pole depends altogether on the location and upon how many obstructions there may be. I find it is most profitable to pike up any pole over 65 feet. I usually take a small pole—about 35 feet long—and place it in the ground about one foot. To this I attach three guy ropes, making them good and fast. I then take a pair of pulley blocks, make them fast to the end of the pole, and make the other end fast to the pole to be raised, in such a place that the butt will be just a trifle heavier than the other end. Then I hitch a horse to the rope and draw the pole up while four men steady it with pikes. A horse will pull it up quite easily, and it can then be dropped down into its place. By this system five or six men can go ahead all day and make a good showing without undue effort. FRANK J. DAVIS.

Derrick on wheels, using horse for power. It takes about 10 minutes to erect a 60-foot pole, from the time they take hold of it until they let it go.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Any pole more than 50 or 60 feet long is too large to be raised with pike poles, and is generally raised with a shear pole or a pair of same. The shear poles must be properly guyed, and a block and fall suspended from top of same. The line from upper block must lead through a snatch block at base of shear pole. The pole to be raised is caught by a lashing about the middle, so that the butt will swing downward when the pole is raised.

A team of horses is then hitched to end of line, and pole is hoisted until it will swing into hole, which for very large poles should be about seven feet deep, and after pole is in place the hole should be properly filled and tamped.

H. S., N. Y. ED. CO.

No. 102.—Is a single-phase, two-phase or three-phase distribution best adapted for lighting in cities of from 15,000 to 50,000 population?

For lighting cities of 15,000 to 50,000 inhabitants—for purely lighting purposes—the single-phase system is perhaps the best. As the single-phase motor does not give the same satisfaction as the two-phase or three-phase motor, I regard the three-phase system as the best with single-phase circuits for lighting and the three-phase circuits for motors. The two-phase would be just as good but for the saving of copper used in the three-phase motor circuit. (UNSIGNED.)

Single-phase, on account of simplicity of wiring and apparatus. F. VAN der VOORT.

The single-phase system is the simplest and usually the most satisfactory in small and medium-sized cities for *lighting* exclusively. Practically, this is, however, a hypothetical case, as some power business can always be secured in cities of 15,000 to 50,000 inhabitants. In that event, the distribution in general could still be single-phase, supplied from two-phase or three-phase generators with the additional wires run out only to where large motors are located. Multiphase transmission can eventually be used should load in any one locality become heavy enough to make this advisable. As between two-phase and three-phase systems, the latter has undeniably many advantages over the former. With old machines of very poor inherent regulation, some advantages have also been claimed for the two-phase system. With modern machines having good inherent regulation and properly designed system with regulators on each feeder, three-phase generators supplying single-phase feeders for power or heavy lighting loads at some distance, is undoubtedly the best and most economical arrangement.

P. JUNKERSFELD.

It depends on local conditions. Three-phase is generally satisfactory and can be used to best advantage for motor or transmission. W. S. BARSTOW.

Single-phase is best adapted for small cities, provided there is no possibility of motive power being required. This, however, is an almost impossible condition. Three-phase system had best be adopted. H. G. STOTT.

Single-phase if city covers a wide area and business is scattered and in small units and only small power business is to be considered. If the city is closely settled, three-phase distribution will prove to be the most economical, and particularly so if power business is to be cared for. There are a great many cities where a combination of the two types of service would be very advantageous, but, in general, the conditions of each city should be studied to determine what is best for its particular case, the choice lying between single and three-phase or a combination of the two; that is, putting lighting on one phase and using third wire for power only.

THE EDISON ELEC. ILL'G CO., OF BOSTON.

Two-phase. P. T., N. Y. ED. CO.

No. 103.—Has the 220-440-volt, three-wire system proved successful and satisfactory in operation? Please state troubles experienced as well as benefits derived.

The 220-440-volt system is successful, but it is a question whether the disadvantages, such as low-efficiency lamps, difficulty in arranging arc lamps and high-voltage motors, do not counter-balance the benefit in saving of copper.

W. S. BARSTOW.

The 220-440-volt distributing system has been in successful operation in California for some time. The great advantage in this system of course lies in the distance that can be reached by secondaries from one bank of large transformers with a reasonable per cent of drop. It is quite easy to reach a distance of three-quarters-of-a-mile radius with this system and still maintain a very good regulation. There are several advantages in using large transformers, as is well known, principal among them being a less percentage of core losses and first cost per unit of capacity. It is also possible with large transformers to allow a less percentage of transformer capacity to lamps connected. Where current is sold on a meter basis, 40 per cent of the connected lights in transformer capacity has been found sufficient. This low percentage of transformer capacity would of course be impractical where small transformers are used for individual houses. It has also been found that these lamps are less sensitive to fluctuations in voltage than a 110-volt lamp. There has been no disadvantage noticed in the use of the system where a good quality of sockets, switches and cut-outs are used. There is a slight tendency to arcing in key sockets, but with a good socket this can easily be taken care of.

C. O. POOLE.

Yes; requires rewiring of old installations; can not use the highest efficiency lamps now obtainable; best adapted for scattered territory. P. T., N. Y. ED. CO.

Only two 220-440-volt, three-wire plants operating in the middle West have come under my notice. I am informed concerning one that when planned it was expected that the load would be almost entirely power, with only a small proportion lighting. The 500-volt, direct-current system was therefore adopted, a neutral wire being provided for the convenience of a few who could be supplied with 250-volt lamps. Had the engineers anticipated the large incandescent lighting load that has been connected, a different system might have been adopted. At another plant the system had been adopted by a predecessor, and the present engineer did not feel called upon to defend its adoption.

Where the power business is a large part of the load this system may well claim careful consideration. But where the load is mostly lighting, or where only a small portion of the power load is intermittent and requires variable speed, polyphase alternating seems to have strong claims.

The disadvantages of the 250-250-volt system gather about three points: the high voltage, the incandescent lamp and the arc lamp. Difficulties from arcing at fuses and switches may be overcome by careful selection of supplies. One would expect trouble on account of the severity of shocks received by customers when the inevitable ground gets on one of the outer wires, or even upon the neutral. The 220-volt arc lamp is not a conspicuous success, largely on account of the strong violet tint due to the length of the arc; the operation of two arcs in series, when the conditions allow, may improve the situation. Since the 220-volt incandescent lamp made its appearance ten years ago, it has come into extensive use, in spite of its lower efficiency. The best lamp manufacturers have not succeeded in making the 220-volt lamp the equal of the 110-volt lamp, and from its nature the problem seems hopeless. For lamps of the same candle-power the higher voltage filament must be longer and of smaller sectional area. It is, therefore, mechanically weaker and will not hold up at so high temperature. For a given life, it seems that the higher voltage lamp must operate at lower temperature and therefore at lower efficiency. This is illustrated by the guarantee made by one of the largest manufacturers, who guarantees four-watt, 220-volt lamps to develop 9500 candle-hours before dropping to 80 per cent of initial candle-power, while they guarantee 3.3-watt, 110-volt lamps of similar type to develop 9777 candle-hours. For practically the same performance the 220-volt lamp takes over 20 per cent more power than the 110-volt lamp. To supply a given amount of light, the plant using 220-volt lamps must therefore have station capacity 20 per cent greater than would be required if 110-volt lamps were used, assuming equal efficiency for the distributing system.

To offset the greater cost of station equipment, is the smaller cost of copper for the higher voltage. According to the elementary theory, doubling the voltage should reduce the weight of copper to 25 per cent. This weight is increased to 30 per cent on account of the lower efficiency of the lamps. The saving in copper is reduced further by the fact that a considerable part of the 110-volt distributing system uses conductors as small as mechanical strength will allow, hence an increase of voltage will only improve the regulation and will not allow the use of smaller conductors. This improved regulation will reduce to an indeterminate amount the difference between the efficiencies of high and low-voltage lamps. The total weight of copper required for the 220-volt lamps will probably be 40 or 50 per cent of that required for an equal number of 110-volt lamps. If the lines are underground the saving in copper is so small a part of the total cost of line that it would not begin to compensate for the greater cost of station equipment. With overhead lines the total investment will be the same for systems with 110-volt and 220-volt lamps when the cost of about half the copper required for 110-volt lamps equals about 20 per cent of the cost of station equipment for 110-volt lamps. The motor load, of course, favors the higher voltage.

It may be urged in favor of the 220-volt lamps that the central station sells energy and not light; that comparisons between various stations are made on the basis of selling cost per kw-hour rather than upon cost per candle-hour; therefore the lower-efficiency of the 220-volt lamp does not stand against the central stations, but, on the contrary, tends to increase the revenue. This argument may hold where there is no competition, but eventually the interests of the consumer and the manufacturer are one. The aim of the engineer should be to furnish the required light at the least cost, and this seems to indicate

against the use of 220-volt lamps, both arc and incandescent, in the majority of cases.
GEO. D. SHEPARDSON.

I beg to submit my experience in operating a station carrying a maximum load of about 5600 kilowatts, 5000 kilowatts of which is distributed on the high-voltage, direct current, three-wire system, the remainder being used for series-arc street lighting.

The system covers a district rather irregular in shape, the most remote points of which are about three miles from the station. This district is all fed from one station centrally located. Standard pressure is maintained at the ends of long feeders by operating two and sometimes three 'busses at different potentials in the station. Eighty per cent of the demand for current is in the underground or subway district, which occupies the central portion of the area covered and constitutes about one-fourth of the entire area of the district covered. The pressure maintained at the ends of feeders is 235 volts between neutral and either of the outside wires. The area of the territory covered by the system of three-wire mains is about nine square miles. All mains, both underground and overhead, are cribbed together into a network, provision being made in the underground district to isolate a main or section of the underground system by means of removing copper catches in cable junction boxes. The system is operated from generator to customer's cut-out or main-line switch without fuses or circuit-breakers, and has given no trouble under these conditions.

The neutral wire is grounded in the station, but insulated at all other points. The system has been entirely satisfactory in operation, and has been in active and successful competition against a well-developed single-phase alternating system operating in conjunction with a 500-volt direct-current power circuit. The system under discussion has had the above-mentioned competition since the day it was first put in operation.

The advantages that have developed are: High efficiency of distributing system (being 94 per cent from switchboard to customer's meter), low cost of maintenance, low first cost per square mile of distributing system, capability to supply satisfactory service over large areas with comparatively small investment in copper, saving in duct and cross-arm space, ability to supply all classes of service from one service connection of three wires and from one generator.

The disadvantages that have developed are: Low efficiency of arc and incandescent lamps; extra care necessary in installing wires for lighting; extra space required for tablet and switchboard; expense necessary in bringing old wiring up to the standard required for 235-470 volts.

It may be interesting to state just what the above-mentioned disadvantages amount to in actual practice. Single-burning inclosed-arc lamps consuming 2.75 amperes are on service on this system and compete successfully with alternating-current arcs consuming seven amperes at 113 volts. Arc lamps burning two in series on 235 volts and giving like service consume 540 watts across the terminals of each lamp.

Incandescent lamps of 16 and 32 candle-power are only accepted when the efficiency is 3.75 watts per candle, or better. The life of these lamps before a drop of 20 per cent of candle-power is about 500 hours. Eight and 10-cp lamps are required to show an efficiency of four watts per candle; four and six-cp lamps are used and are burned two in series on 235 volts. The extra care required in installing wiring for use in connection with this system simply means the use of rubber-covered wire wherever the three wires are run in damp places; slow-burning weather-proof wire is used for open work where dry conditions prevail. Fibre-lined sockets, long-break cut-outs and switches are also required. Standard quality of flexible cord is used with entire success.

To obtain the space required for tablet boards is sometimes inconvenient, although this difficulty has never yet caused the company operating the system to lose a prospective customer.

S. B. WAY.

No. 104.—How may the swinging lead wires from cross-arms to arc lamps be prevented from breaking?

We have no trouble when using flexible leads; either single leads or duplex cable. I doubt if there is any thoroughly effective method of preventing breaks if a solid conductor is used for a lead. If the flexible lead is carried to the cross-arm and attached thereto, so that the connection to the line is made between the cross-arm and the line (so that the solid conductor has no strain), there should be no trouble, judging from our experience.

GEO. B. LAUDER.

Swinging lead wires from cross-arms to arc lamp may be prevented from breaking by either of the two following methods: First—Use a good grade of stranded cable, comparatively light in weight, and connect it to the line just before it reaches the glass on the cross-arm from which the lead wire is to be taken, and use this stranded cable as a lead wire. In tying it in at both ends let your tie-wire extend along the cable for several inches, as this will make the bend, caused by swinging, longer. Second—Use ordinary solid line wire, but at each insulator, at both the lamp and cross-arm, make a coil of about four turns and about three-quarters of an inch inside diameter. Support the weight of the wire by a stout hemp cord or light rope that has been dipped in pitch, by tying it just beyond this coil and to the insulator. In this way the swinging of the wires is taken up in the coil and the wire does not crystalize and is not liable to break. L. E. WATSON.

Inserting a piece of flexible conductor at the ties on pole and lamp, will greatly reduce the liability to breakage.

O. H. SKIDMORE.

Connect No. 6 stranded cable around insulator and from lamp hanger to binding post in lamp. We have used this method for 12 years and have found it very reliable.

THE SHERBROOKE PR., LT. AND HT. CO.

I have had much trouble with the breaking of the leads to arc lamps, but I have entirely overcome it by using flexible leads and placing a jumper on the main line and lead where the lead connects to the main line on the cross-arm insulators, and by twisting the wire on which the lamp is suspended, thus forming a loop or ring through which the lead passes through down to the terminal. This ring is about 15 inches above the terminal of the lamp. This ring method prevents the wire from breaking where it enters the terminal of the lamp, as all of the strain or hinge motion caused by raising or lowering the lamp and by the blowing of the wind, is entirely removed. I have been using this method about three years and none of the leads have yet broken. I have quite a number of lamps where the leads are just ordinary line wire, arranged as described above, and none of these have broken. ERNEST LUNN.

By dead-ending the line at pole, then securing a break-knob to line insulator by a fairly rigid iron wire. Pass the lead wire through the hole in the break-knob and dead-end it. Finally, interpose a close-wound helix of stranded copper wire from line to lead wire, forming a flexible connection. The break-knob acts as a hinge and eliminates any bending movement of either line or lead wire occasioned by raising or lowering lamps or by swaying. GUY C. GUM.

If swinging lead wires from cross-arms to arc lamps are made of No. 6 B. & S. stranded cable of about 48 strands, very little trouble will be found from wires breaking off at cross-arm pins or arc binding posts. The same results may be obtained by splicing on about four feet of stranded cable to each end of the swing lead wires. C. W. HUMPHREY.

Swing lead wires from cross-arms to arc lamps may be prevented from breaking by using flexible cable of fine wire and attaching the same to insulated spreaders fastened to the top of the lamps. E. H. MATHER.

The swinging lead wires from cross-arms to arc lamps may best be prevented from breaking by twisting the lead several times around the wire that is a part of itself, on the other side of the insulator; that is, instead of fastening the lead with a tie-wire and carrying it to a lamp, take the lead around insulator, as if you were going to tie a dead end, then follow with several loose turns, which makes a spiral on the tight wire. The spiral acts as a kind of spring. CHAS. H. PETERS.

The breaking of swinging lead wires on arc lamps has been very greatly reduced in Chicago by the insertion of a short length of heavy rubber-covered No. 6 cable in the circuit at points where breaking occurred most frequently.

H. B. GEAR.

The writer tried a scheme which is as follows: Where the swinging leads of the arc lamps were tied on to the insulators (both leaving the pole and on the lamp), connecting a piece of flexible cable on in such a way as to bridge the "open" in case of breakage of the wire caused by the swinging leads. This scheme was in use by the writer for more than three years, and there never once was an open circuit caused by the lamp leads breaking. G. B. LELAND.

By the addition of a spreader. The lamp should be hung from the centre of the spreader, and the ends of the lead wires tied into or around the insulators on each end of the spreader. Connect the lamp to the lead wires by a short loose loop of soft flexible wire sweated on to the lead wires back of the tie on the spreader insulator. This method eliminates the direct strain on the lead wires due to swinging, raising or lowering of the lamp. It also provides a large binding or clamping surface for holding the ends of the lead wires rather than the small bearing obtained with a set screw holding the entire lead loop in the lamp binding post. S. G. R., N. Y. ED. CO.

Having had the trouble indicated in this question, we have fitted all of our street arc lamps with twin flexible wire. Although this is rather expensive in first installation, we have had absolutely no trouble since this time and we think the extra expense justified.

YOUNGSTOWN CONSOL. GAS AND ELEC. CO.

No. 105.—What is the best method of protecting wires, carrying current of 1000 volts and upward, from grounds on trees through which they must pass?

We have found no way of protecting our wires from small branches of trees, but where the wires run through large branches we have used tree insulators with very good results. Our only remedy with the small twigs has been to trim them off. F. ELLWOOD SMITH.

We have tried all kinds of schemes, and we now confine ourselves to trimming the tree, if we can; if not, we get off the tree. We sometimes use a split knob, or some similar device, and pass the wire through the knob and pull the knob away by a bridle of wire, so that it will not hit a limb. The bridle allows the wire to swing a little in all directions, and we have found the insulation to be enough for our 2500-volt direct lines.

GEO. B. LAUDER.

Suitable tree insulators where they will be allowed and where the wires pass through trees at a point heavy enough to attach tree insulators. For voltages of 1000 or 2000 the smaller branches will probably give comparatively little difficulty even in wet weather; for heavy voltages, the wire should be kept out of the tree, or tree trimmed clear of them.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

We have found that the ordinary split insulator does not give sufficient insulation to our primary wires carrying 2300 volts when used on trees; on the contrary, if the lines are rigidly tied to a glass on a bracket the swaying of the trees works them loose. We therefore combine the two, tying the split insulator to the glass on the fixed bracket, and then running the primary through the split insulator, making sure that the insulator tends to pull the primary down slightly to prevent it from swinging on to the bracket. This arrangement has been very successful.

CHARLES G. BELL.

For a number of years the Brush Electric Light Co., of Philadelphia, put in practical use the various devices that were on the market. It was determined in a short time that such devices did not eliminate the trouble, but in many cases multiplied it by the constant wearing away of the wire until the cross section was not sufficient to withstand the strain of the span, thus causing wire to break. The class of devices referred to includes all that are rigidly attached to large limbs of trees and provided with various methods of supporting a porcelain or glass insulator as a roller.

Our next experiment was the use of circular-loom conduit, sufficient in length to pass through the branches of the tree and extend three feet outside the branches at each end. This conduit was specially treated with a thick asphaltum paint, and slipped over the ordinary line wire. In time, the conduit became soft and places were chafed through it by large limbs.

Our next step was the use of flat ribbon steel-armored wire. We found that the large limbs of trees would turn the armor up edgewise sufficiently to cut through the insulation and place the entire length of steel armor in circuit.

About five years ago we adopted the use of rubber-insulated wire, and are using the same to-day. Our potential on aerial lines ranges from 1000 to 5000 volts alternating current and 1000 to 6500 volts direct current (series arc). We use for protection through trees a wire having insulation of five-thirty-seconds-inch pure rubber, protected with a double braid of coarse jute treated with a weather-proof compound. A section of this wire, sufficient in length to pass through the branches of tree and extend three feet outside of the branches, is inserted in the line, and a wood sleeve (made in halves) twenty-four inches in length is used for protecting the rubber wire from large limbs or trunk of tree. We make a practice of using the same wire and method of protection for 1000 volts that we use for the 6500 volts, thus making our 1000-volt lines adaptable to 6500 volts if at any time required. A. H. MANWARING.

Split porcelain tubes. W. S. BARSTOW.

Cut limbs off trees between midnight and daylight. The next best thing is a tree insulator which is attached to the limb by means of brackets or drive screw. This device consists of a double-petticoat glass insulator provided with a porcelain pulley on which the wire rests and through which it is free to slide. Where the lines are too small to attach these insulators, cover the wire with wooden protectors to prevent abrasion of insulation.
W. T. M., N. Y. ED. CO.

No. 106.—What is the best protection for telephone lines strung on poles carrying high-tension circuits, or on separate poles at such distance from high-tension poles that there is a possibility of high-tension wires falling or being blown upon the telephone wires?

If the wires mentioned are close enough to come in contact by wind-swing, it would be best to move telephone wires to a safe distance. If merely strung directly below high-tension wires, it would be best to place a special arm on poles between the leads, stringing thereon, at each extreme of this arm, a single steel wire, tying in a span across these lines every 20 feet. But if careful linemen are employed, the lines can be so put up that they are safe without any such device.
O. H. SKIDMORE.

Guard wires. W. S. BARSTOW.

tion of which I am aware that allows of small air-gaps for high tension, and yet it acts without any mechanical arc-breaking devices. Instead of putting an end to an arc due to the normal current following lightning discharge, this combination prevents the formation of the arc, by primarily barring the current. On account of the smallness of the air-gap, the safety of the lines is greatly increased. In fact, such a contrivance will act as a line discharger, relieving the line of the ordinary smaller atmospheric disturbances.

JOHN F. KELLY.

Standard lightning arresters, and, possibly, some additional circuit gaps installed at suitable points, circuit gaps being set for lower strains than the lightning arresters.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Mr. F. R. Cutcheon, of St. Paul, has devised a lightning arrester with several air-gaps and connecting with different portions of the winding of the transformers, with one air-gap intervening between each of these connections, which I think will prove a very valuable means of protecting transformers from excessive strains. HENRY L. DOHERTY.

We have had a good deal of experience along this line, not all of which has been successful, however. We have used non-arcing lightning arresters with choke coils at our generating plants. While we know that choke coils are bad, lightning is worse. This arrangement has not been entirely satisfactory, on account of the long distance between stations; several poles have been split in pieces by lightning discharging down the pole.

Our telephone line runs on the same poles with the transmission line, about five feet below. This line is insulated with common double-petticoat insulators and run on brackets. I have found that in most cases poles have been split from the telephone line down, while a few have been split from the braces of transmission arms. This looks to me as if a line that had the least resistance to earth were the line most subject to lightning discharges, and we have equipped 46 miles of line with a wire parallel to the transmission line and have grounded every third pole. We are just completing this work and have had no chance to judge the results that we hope to obtain in this way.

With a grounded line on the poles, it is, of course, necessary that the transmission line should be more carefully insulated. I regret that I can not give you more definite information on this subject, but believe that in another year we shall be better informed. H. C. HOAGLAND.

The question of lightning protection is a very deep and important subject, and what might be considered a safe protection in one locality would be utterly useless in others. On the Pacific coast we have found it good protection to use several choke coils in series on each leg of the transmission line, with several independent paths to ground through large surface arresters. In addition to this we have used a modification of the Siemens horn arrester connected to the primary line on the outside of the choke coils. A fixed resistance should be placed in each leg of the horn arrester to ground, to limit the current when the arc jumps across the arrester. This combination has proven quite successful on long-distance transmission lines of voltage up to 40,000 volts. When an extreme rise in potential comes upon the line, either from lightning or sudden release of short-circuit, the horn arrester will hold the voltage down within a reasonable per cent of normal, and when the arc breaks between the horns by decreasing of voltage due to the partial short-circuit by the arrester, the lightning arrester will then take care of the line. C. O. POOLE.

The best method known to us for protecting transformers, etc., from lightning and other static strains, is a set of choke coils and non-arcing arresters. Several different arrangements of these arresters have been used by us, and while they are not an absolute protection, still we have had very little trouble with transformers thus protected. We have not given the low equivalent arresters and static interrupter a trial as yet, but expect to do so. A. L. WOODHOUSE.

Installation of improved lightning arresters at all terminals of transmitting line and barbed wires on poles. Avoid switching high-tension side of transformers and also single-pole switches.
P. T., N. Y. ED. CO.

No. 108.—What is the latest practice for prevention of explosion of lightning and sewer gas in conduits?

Ventilation of manholes and conduit.
W. S. BARSTOW.

Explosions of gas in manholes are best prevented by using ventilated manhole covers and by keeping the cables in good condition so that there is no chance for a spark or flame to ignite the gas. If the continued presence of gas is noticed in any manhole or group, the gas company should be notified.

W. G. CARLTON.

The best practice is to use double manhole covers, the upper one of which is perforated with a large number of holes, the lower one being merely a shield to keep the dirt from falling down into the manhole, and thus allowing the gases to pass off freely into the atmosphere.

H. G. STOTT.

We are using perforated covers for our manholes and are having comparatively little difficulty.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

All manholes and distributing boxes should be provided with perforated covers. Experience has shown that there is sufficient circulation through these ventilated covers to keep the conduit system practically free from explosive gases.

Precautions: 1st. Provide the manholes with ventilating covers, as described.

2d. Keep the openings of these covers clean.

3d. Keep the manholes as clean as possible and as free from water and dampness as possible.

4th. Seal up the subsidiaries and laterals carefully at the ends.

5th. Have sewer drains well trapped.

6th. Keep gas mains in the vicinity of conduits in good repair.

7th. Keep gas mains as far away from conduits and manholes as possible.

8th. Take all possible precaution against burnouts.

9th. Protect the conduits and cables from mechanical injuries caused by other excavations.

J. B. N., N. Y. ED. CO.

In the latest practice for the prevention of explosions due to illuminating and sewer gas in conduits, the tendency appears to be toward the use of perforated manhole covers and other means of natural ventilation ; and the gradual disuse of artificial ventilation, such as by blowers.

WILLIAM MAVER, JR.

No. 109.—In a 10,000-volt line—15-mile line over mountain country—our banks of arresters keep continuously hissing when lines are hot. They did not hiss last year, but do now. Why? Arresters also will hiss when not attached to ground wire. Why? We also note that building up arresters from four to five blocks makes no difference. Why?

I am somewhat in doubt as to my comprehension of this question. The disturbance referred to seems to be atmospheric in origin, and, if so, it ought to be cured by any good line discharger. I have seen a bank of lightning arresters not over-well insulated spitting between the upper members. The leakage from the upper members and the consequent dissipation of the charge protected the lower ones from spitting. Had the lightning arresters been thoroughly insulated, I have no doubt the spitting between the lightning-arrester members would have ceased, but at the expense of increasing the strain on more important organs of the system. The low insulation was a poor way of accomplishing the desired result.

JOHN F. KELLY.

If the ammeters are cut directly into a 10,000-volt line without the intervention of transformers, the hissing noises may be due to one or two causes. First, there may be a creeping to ground through the ammeter ; second, there may be sufficient surface in the ammeters and the parts to which they are connected to give static capacity sufficient to cause the hissing. This is especially true of large banks of lightning arresters.

C. O. POOLE.

We note a very great difference in the behavior of our various arrester banks. The nature of the geometrical arrangement of these arresters, their proximity to walls, etc., the nature of the frames in which they are placed, and many other incidents of their location and arrangement, seem to have a strong effect upon the charging current taken by a bank of arresters.

A. L. WOODHOUSE.

The hissing is probably caused by a static charge on the line, due to the dry air of the mountain region. This naturally discharges on the switchboard instruments and lightning arresters at station, which have a poorer insulation than the line. When the line was new and the poles and cross-arms were damp, this, naturally, was not the case, and the static was discharged on the line and was not noticed. The hissing could probably be taken care of by reducing the number of air-gaps in the lightning arresters. They should be so connected as to give them the same number of gaps between each pair of wires, and any wire and the ground. Building up blocks would increase the number of gaps and would rather tend to make things worse. W. T. M., N. Y. ED. CO.

It looks as if you had run into a case of minor resonance, resulting in abnormal potentials. Possibly this may be complicated at times by atmospheric charges. If the hissing is nearly continuous, the latter cause is probably of small account, while if the hissing seems to vary with the load conditions, it is due mainly to resonance. If it varies markedly with atmospheric conditions, static charge from the atmosphere plays at least a part in the phenomenon. Ordinarily, one may expect hissing on a 10,000-volt line, but its presence when arresters are not grounded shows a much greater amount of disturbance than usual. Remember that resonance is not determined merely by the inductance and capacity of the line, but by the constants of all the apparatus connected as well, and that slight grounds or other faults may greatly modify the conditions that determine resonance. I have seen most vicious resonance produced by a sudden change of load, even apart from the ordinary singing that results from opening a switch. If your arresters hiss when disconnected from the ground wire, changing from four to five blocks could not be expected to make much difference. It would be well to keep watch and see at what times in the day hissing is most prominent or starts up, as thus you may trace it to a particular source. If you have a synchronous motor on the system, keep an eye on it, and when you get a good chance, try sawing the field current up and down, meanwhile noting the effect on the hissing of the arresters. Shunting part of the arrester gap to earth *via* a very high resistance sometimes has a good effect, as, in fact, anything will that tends to keep the line discharged while avoiding risk of a short-circuit following. I should be glad to hear further particulars of the phenomena, as they develop, especially the effect of changing load.

LOUIS BELL.

The load on the lines this year is probably different from that of last year, and the different amount of armature reaction causes a difference in the shape of the current and electromotive-force curves. This change in the strength of the harmonics lessens the amount of resonance with its consequent high local electromotive forces and tendency to sparking across the static arrester.

GEO. D. SHEPARDSON.

No. 110.—In an alternating-current station equipped with three-phase generators, is it not better to run all lighting load on one phase and adjust voltage of this phase to suit the lighting circuits, paying no attention to either of the other phase voltages and using the three phases for power work only, buying machines designed to handle the load in this way, rather than to attempt to balance lighting load on all three phases and adjust the three-phase voltages to suit load?

This would seem to depend upon the relation of the amount of lighting done to the amount of power. It has never seemed to me that the scheme of using one phase for lighting allowed the full benefit of the three-phase system. The unbalancing of the phases is certainly a trying annoyance, but we have thus far kept cutting the load over, until we have a good balance most of the time. Machines especially designed for carrying a greater load on one phase might help solve the problem, but such a system would seem far from symmetrical. Our lighting load is about equal to our motor load, and such a scheme would hardly seem advisable; there would certainly be a large difference in voltage on the three-phase, even for power, unless the whole system were laid out properly. I doubt if such an arrangement would be desirable where the lighting load was large.

GEO. B. LAUDER.

A station having a number of circuits generally has no trouble in so placing the circuits on the three phases as to obtain a balance on the machines that is good enough for all purposes. Where a number of circuits are operated, feeder regulators are a necessity for proper regulation of individual feeders, and in view of the introduction of automatic feeder regulators no gain would be made by having a generator constructed specially to carry an abnormal part of its capacity on one phase. Again, there are strong objections to the use of such machines, as they usually involve a higher first cost, with the additional difficulty of obtaining parts for repairs.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

It is best and cheapest to operate a three-phase plant three-phase throughout. For lighting, use the four-wire system, whereby you have the alternative of 110 and 220 volts, or, if you prefer, 220 and 440—and keep all three phases balanced and voltage equal. You thereby eliminate a potential regulator, which requires contact points that become burned in operation, and will probably lock your switch at the moment when it is most important that you should use it.

O. H. SKIDMORE.

In alternating-current stations equipped with three-phase generators, I regard it as good practice to put regulators in each phase and to balance your load as nearly as possible on the line, and thus give proper voltage on both the lighting and motor circuits, for it is often found desirable, where motors are installed, to put lights on the same service. (UNSIGNED.)

The writer used such an arrangement very successfully in a small plant that had a combined load of lights and motors. The voltage of the lighting phase was controlled by an automatic potential regulator, and no attention was paid either to balancing the phases or to the potential of the other phases. The motors, drawing the most of their load from the unused wire, made scarcely any disturbance on the potential of the lamp circuit; this was the case under various conditions of lighting and motor loads. As was to be expected, the voltage of the three motor legs varied, but no bad effects occurred therefrom. H. BOTTOMLEY.

Balance lighting on three-phase, and adjust three-phase lighting to suit load. W. S. BARSTOW.

In an alternating-current station with three-phase generators and at least a considerable number of single-phase circuits, feeder regulators should be used. Under most conditions, circuits can easily be arranged and loaded to give a fair balance. With good modern alternators and ample capacity in feeder regulators, such unbalance as will occur at times does not harm. If single-phase circuits are operated all on one phase, there is a sacrifice of 25 per cent to 40 per cent of capacity in generating units, depending upon the manner in which single-phase circuits are connected to three-phase generators. P. JUNKERSFELD.

Depends on percentage of lighting load to total load ; under average conditions, yes. P. T., N. Y. ED. CO.

No. 111.—In a plant of 3000 lights' capacity, single-phase, 60-cycle, primary 1040, secondary 104, seven and one-half miles pole line, 250 consumers—what in good practice would be the loss from the station switchboard to the consumer's meter? Plant furnishes current for lights only ; run from dusk to dawn.

There appears to be doubt as to the exact meaning of this question, some answers giving the allowable drop in potential and some the loss in energy. EDITOR.

The loss ought not to be more than three volts at secondaries. A. O. FRETZ.

The allowable loss would depend somewhat upon local conditions. If feeder regulators are used the circuits can usually be arranged for as high as 10 per cent loss and still get good regulation ; or if the station is located at a considerable distance from its centre of distribution fairly good results can be obtained without the regulators, as only those few lights close to the station would suffer from high voltage. The loss should be about as follows : Six per cent in the primaries, two to two and one-half per cent in the transformers, and two per cent in the secondaries. C. C. GILES.

Ten per cent would be the maximum into which good service would be run.
THE EDISON ELEC. ILL'G CO. OF BOSTON.

In an electric-light plant of 3000 lights' capacity, single-phase, 60 cycles, primary at 1040 and secondary at 104 volts, with 7.25 miles of pole line and 250 consumers, good practice would show the following distribution of losses in per cent of output:

	Per Cent
Transformer core losses	4.5
Meter shunt losses	2.0
Primary resistance losses	3.0
Secondary " "	2.5
Lost and unaccounted for	10.0
Efficiency of distribution	78.0

These percentages are based on the assumption that the monthly output is in the neighborhood of 11,000 kilowatts, and the transformer capacity about 50 kilowatts. Of course these losses vary somewhat with the nature of the load, method of secondary distribution, and sizes of transformers used.

C. W. HUMPHREY.

It depends on the system of distribution, but an average loss of five per cent would be likely. W. S. BARSTOW.

Under the conditions stated, and assuming that the load is of fairly uniform density in entire area covered, a loss of 30 per cent to 40 per cent would usually be considered allowable. A further reduction in losses will usually mean an investment in secondaries greater than the savings effected will warrant. A few large consumers, located near each other, make it possible to reduce losses considerably. P. JUNKERSFELD.

Twenty-five per cent, exclusive of low reading of meters.

P. T., N. Y. ED. CO.

No. 112.—What is the best method of locating grounds on an Edison three-wire underground network system?

Subdivide the system into sections, keeping each section on separate feeder, and locate ground in one particular section. Transfer mains from this section to the rest of the system until ground is located on the main or feeder. After having located ground on main or feeder, divide the line in the middle, and test both ways, subdividing until the fault is located. Other methods, such as telephone bridges, etc., have not proved successful up to the present time. W. S. BARSTOW.

In practice, we find that the best method of locating grounds on Edison three-wire underground network is to burn off the ground and then locate the point where the main is open. The place where the burnout occurs can be located by testing at the services along the line. One or two openings in the street will usually suffice to locate the trouble. In case ground can not be burned off, the trouble may frequently be located by digging where other work has recently been done in the street, or by opening main at point where service connection is made for important customers, and testing either way. The rapidity of restoring service to customers will compensate for any extra openings that may have to be made to locate the ground. Other methods have been tried, but with only partial success.

HOMER E. NIESZ.

Edison Tube Feeders. Trouble is first located by the effect it has on feeder ammeters in station, and as many feeders pass through junction boxes, to enable cutting into sections by removal of fuses or links, the bad section can be located in this way and cut out, the good sections being kept in service. When grounded section is found, the "cut and try method" will usually be employed.

Edison Tube Mains. Trouble on mains is first indicated by station instruments, complaints from customers, or when junction boxes are open for inspection; mostly in the two last-named ways. The house connections on the grounded or open main are then tested and the trouble is located as nearly as possible in this way, when the "cut and try method" is used.

"Loop-services" are a great advantage in locating main trouble, and also secure the customer against a lengthy interruption of service in case of burnout of main.

The "slide wire bridge" and "telephone and interrupter" systems have been tried, but with little success on Edison tube, owing to the number of joints and low insulation resistance.

Cable Feeders and Mains. On cable feeders and mains, in addition to the above-mentioned methods, grounds are successfully located by the use of a bank of lamps controlled by a reversing switch connected to bad conductor and ground, and by then following along cables in manholes with a compass, which will show deflections, according to direction of current, until ground is reached, when deflections will cease.

H. S., N. Y. ED. CO.

No. 113.—What would be the best and cheapest method of underground wiring for a small town?

The cheapest is not always the best. Vitrified conduits are the best; creosoted conduits are the cheapest.

W. S. BARSTOW.

The question of placing wires under ground depends not so much on the size of the town as on the density of the load to be taken care of. There are few places where it will pay to take a scattered residence load on underground lines, while it is frequently possible and advisable to go underground in a concentrated business district. The system to be employed in underground work depends largely on the general system used for lighting. Generally speaking, a cable and conduit system is the most satisfactory, though for low-tension work over comparatively short distances, an Edison tube line will be satisfactory, and cheaper to install than the cable and conduit.

W. E. CARLTON.

This would depend entirely upon the nature of the town, that is, whether customers were spread over a comparatively large territory or rather congested. If they were close together and did not spread very far, a low-tension system would be desirable, and the cheapest way to install this would be with the Edison tube system; if the territory extended over a large territory, cable and conduit system would be very much cheaper, as high-tension distribution could be used with this, putting transformers in manholes and running individual customers from the regular manholes at the corners without the introduction of a large number of manholes.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

In laying out an underground system for any town there are always peculiar local conditions to be considered.

Conduits. In the majority of cases a direct-current supply in a conduit or drawing-in system built of tile duct for both trunk and distributing lines, and manholes with inexpensive fittings at street intersections, can be used. The handholes on distributing lines can be constructed when house-service connections are made, by breaking the tile ducts and building the walls of brick or concrete, which can be brought to the surface by simple castings; or it would be cheaper to cover mason work with iron plates or pieces of flagstone and paving over same, thereby making a "buried box."

Cables. Paper-insulated cable with lead armor is considered cheapest for mains and feeders in towns where there is no leakage from electric railways; however, where much trouble is experienced from this source rubber-insulated cables should be used.

Junction Boxes. It is advisable to locate fused junction boxes at all points where feeders connect to main network, to simplify the disconnection of feeders from the system in case of trouble, for testing purposes.

Service Connections. Rubber-insulated cable with lead armor in iron pipe is considered good construction for house-service connections, as when paper-insulated cables are used for this class of work the house ends require considerable attention.

H. S., N. Y. ED. CO.

We have had lines carrying 1000 volts (alternating) primary for four years—one-eighth inch rubber, no lead, laid in fibre conduit—which has given no trouble. We have dirt roads and sand subsoil. Population, 2,000.

SOUTHAMPTON ELECTRIC LIGHT CO.

If by underground wiring is meant underground cables and conduits, probably the best and cheapest method for a small town would be to place paper-insulated cables in three-inch earthenware ducts laid carefully in cement, with manholes at suitable distances apart; the number of ducts, size of manholes, depth below surface, etc., to depend on local conditions.

WILLIAM MAVER, JR.

No. 114.—What has been the experience in operating an alternating-current system of from 1000 to 2000 volts in conduit that is more or less filled with water?

We have had several places where our conduits were more or less filled with water, but have never had any trouble with the cables. We use the best quality, lead-incased, rubber-insulated. WALTER L. MULLIGAN.

No difficulty with 1000 volts. F. VAN der VOORT.

The more water the better. Lead sheathing on cable should be ample protection against water, and if the cables are under water possible burnouts are very much less destructive.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

We have opened some of our conduit and found it filled with water; no breakdown or appreciable difference in service had occurred.

SOUTHAMPTON ELECTRIC LIGHT CO.

No. 115.—What remedy should be applied to overcome the humming of telephones, caused by series-alternating arc-light circuits?

The common way to overcome this difficulty is to transpose the telephone wires at regular intervals. The telephone company sometimes asks that the electric-light circuit be run in parallel return. If this does not overcome the difficulty, I think it is the practice of the telephone company to put its wires in a cable.

F. ELLWOOD SMITH.

We have found it a very difficult matter to overcome the humming of telephones, even after spending no little time and money. The trouble seems to be caused in part by induction, but principally by leakage. The following will help decrease the trouble:

Very careful and thorough insulation of *both* electric-light and telephone circuits.

Putting the electric-light and telephone circuits as far apart as possible on the poles.

The transposition of the telephone circuits.

We have tried, without any apparent beneficial results, the transposition of the electric-light wires, and also placing them close together. We believe that the trouble can be overcome by placing the telephone wires in aerial lead-covered cables and grounding the sheathing.

We would repeat that thorough and careful insulation and the clearing of both circuits from grounds, are very important. We would refer to the exhaustive articles in the *Electrical Review*, March 28, 1903, pages 441 to 447, inclusive.

ALEX. J. CAMPBELL.

Straight metallic telephone circuits are not materially affected. An obvious remedy, therefore, would be to do away with all ground return and selective party lines. However, the noise can be reduced by having the arc lines entirely free from leakage to the earth and by keeping the two wires of a circuit on the same pole line as much as possible. If two wires, one each of two different circuits, are on the same pole line, and the circuits are run from the same machine, have the wires of different polarity. C. C. GILES.

By improving the general insulation of both telephone and series alternating arc installations; by separating the two systems as far as possible from one another; and by suitably transposing the wires of both systems. P. G. GOSSLER.

No. 116.—What has been the experience in making service connections with underground alternating-current system; particularly with regard to use of fuses in junction boxes, location of transformers in manholes, and detail methods of secondary distribution?

The ordinary feeder and main system, as used on low-tension work, is very satisfactory for alternating-current underground work, the transformers being the feeders to the secondaries. It is necessary to have fairly dry manholes, preferably with sewer connections, for transformers. Transformers should be fused on primary side, and if a number are working in the same main they should also be fused on the secondary side. All fuse boxes used should be of iron, and the doors should be provided with rubber gaskets. Cables entering boxes should be so protected that water can not get into the boxes. Mains should be separated by junction boxes at suitable intervals, so that an accident to one portion would not shut down the whole or a large part of the network. W. G. CARLTON.

We have been using transformers in manholes with secondary mains running out from them for a number of years. We have used fuses in junction boxes for customers' taps only to a very limited extent; we have not found them particularly advantageous. These fuse boxes were installed only in manholes from which a number of customers were supplied, and were put in boxes because they made a better job in the manhole than the large number of branch connections made directly on the cable would have made. We have never used fuses in the secondary mains, as we have not found any need for them;

every case outside of the building. This will obviate the danger of lightning or other high-voltage current entering the building.

HOMER E. NIESZ.

The national code does not permit of grounding secondaries inside of buildings.

PEORIA GAS AND ELEC. CO.

Grounds at the transformer are much preferable if they can be obtained, as two or three customers are supplied from one transformer. Grounds at the transformers, however, are practically impossible to get in certain districts. In such cases, we can see no objection to grounding the wires in the building supplied, provided the ground wire is located between the transformers and any service switch or fuse.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

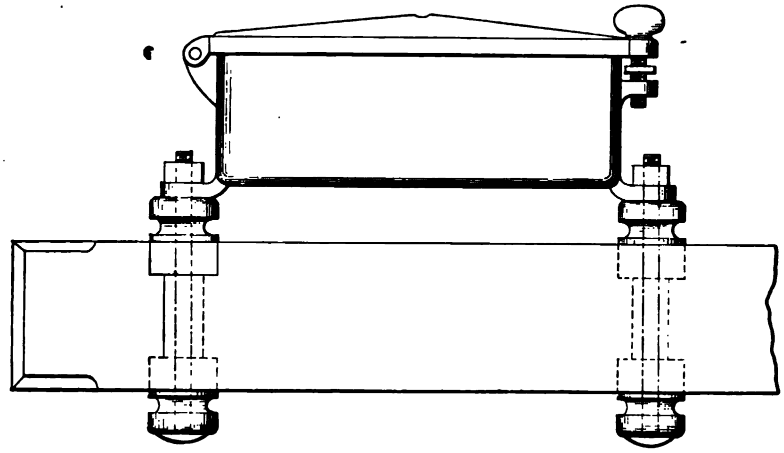
I believe it is best, as a general rule, to ground the secondary near or at the transformer, rather than in the building supplied. If the ground connection were made inside the building, lightning would have to pass through more or less of the building on its way to earth. If the earth connection is of high resistance, or becomes accidentally broken, there is greater chance of fire and more danger of customer receiving a serious shock than if the ground is well inside the building. I can see no reason for making the connection inside, other than that it is sometimes easier and cheaper to make an effective ground with interior piping than it is to make such a ground outside. The same piping, however, is usually accessible outside the building, and no great labor is involved in making suitable connection with it under ground.

WALTER S. MOODY.

No. 119.—What is the weight per kilowatt capacity and the cost per kilowatt capacity of the Cooper-Hewitt static converter?

No. 120.—What is the best transformer fuse box for 2000-volt alternating current, and why?

We have had eight years experience in operating 2000-volt alternating current, and have always had trouble with the transformer fuse boxes until January, 1900, when we began using a transformer and branch-line fuse boxes using the non-arcing fuse, which were absolutely non-arcing, but gave trouble in bad weather until I devised a method of insulating the box from the cross-arms, as shown in cut. This is a cheap and quick method of mounting the boxes on cross-arms before putting same on poles. We have since had no trouble whatever with grounding or arcing, and can recommend this method as absolutely reliable.



METHOD OF MOUNTING PRIMARY FUSE BOX ON CROSS-ARM FOR 2000-VOLT ALTERNATING CURRENT

GEO. S. CARSON.

Single-pole porcelain boxes of the line-insulator type are the best, because there is no danger of short-circuits, and the danger to employees from shock is reduced to a minimum. They are also cheaper. C. C. GILES.

The writer considers the porcelain line-insulator type of fuse box as being the best on the market at the present time, both as regards ease of installing and replacing burned-out fuses should occasion require.

This answer would also apply to questions Nos. 160 and 161.

G. B. LELAND.

No. 121.— What is the advantage to an alternating-current station in carrying a secondary voltage much in excess of 100, unless it has an extensive system of secondary mains?

One advantage is in residence lighting, where the territory to be covered is comparatively large and still it is very desirable

to have several consumers on each transformer. Multiple arc lamps will burn more steadily on from 110 to 120 volts than on 100 volts.
C. C. GILES.

The advantages in using voltages in excess of 100 volts for secondary distribution are: Better regulation, due to decrease in copper loss. Larger transformers may be used and placed farther apart with same secondary loss. But 200-volt lamps are not so efficient as 100-volt lamps, therefore I think that the most efficient method is to use three-wire secondary distribution with 100 volts on a side and using 100-volt services. In this way the advantages of 200-volt distribution may be obtained without impairing the lamp efficiencies in any way.

C. W. HUMPHREY.

We can see no advantage.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

There is no marked advantage except in decreased losses in secondary mains. On the other hand, the core losses and heating of transformers are considerably increased.

EDITOR.

A different standard voltage for different companies is desirable for obtaining more uniform lamps from manufacturers.

P. T., N. Y. ED. CO.

As a rule, the saving in copper due to using voltages from 115 to 130 is very small as compared with that necessary for 100 volts under the conditions supposed. There are few plants, however, so small that it does not pay to have a system of secondary mains where the demand for current is greatest. Most station managers object to the use of different voltages in different parts of the system. Therefore the higher voltage lamps are desirable because there is a saving in copper by their use, in a certain part of the installation at least.

The second, and perhaps the more important consideration, is that most alternating-current motors are designed for a voltage of about 110 or 220. The use of a lamp voltage at least as high as that for which the motor is wound is therefore advisable, in that it is not necessary to have transformers having different ratios of transformations for motors and for lighting.

WALTER S. MOODY.

No. 122.—What is the consensus of opinion regarding tying in secondary wires from different makes of transformers? Have central-station managers adopted the practice generally, and with what results?

We have a belt-line, three-phase distribution, about two miles in circumference, on which there are 27 transformers connected into the same set of secondaries. These transformers are separated from each other several hundred feet, more or less, so that the line resistance tends to distribute the load. They are all of one make, although of different types, sizes and cycles, corresponding largely to different makes. We have had uniformly good success and advocate the idea where it can be used to advantage. GEO. B. LAUDER.

Care must be taken in using different makes of transformers, or even different sizes of the same make, with the secondaries in parallel, to make sure that they have the same percentage of drop in voltage at full load; otherwise, the one having the least drop will take more than its share of the load when fully loaded, although acting well when the load is light. This difficulty can be overcome by using comparatively small wires to connect the transformer having the least drop to the secondary mains, thus, by properly proportioning, making the total drop for the two transformers the same. C. C. GILES.

I have experienced no difficulty in uniting transformers of different makes, sizes and types. I prefer cross-connected secondaries in a single unit; this is more economical and less unsightly. Practically, there is no objection, that I can see, to using different makes connected in any manner to secure desired results, provided both are fairly well mated in voltage and regulation. GUY C. GUM.

Tying in secondaries of different makes of transformers with variable load can be done successfully only when transformer loss is considered as part of feeder loss and transformer pressure regulated accordingly. W. S. BARSTOW.

We should say that this was bad practice, as different makes of transformers have different characteristics, and on apparatus of different drop the amount of work put on to the different transformers might differ very materially. We have not adopted this practice.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

In a very few cases the regulation of transformers of different makes would be near enough alike to allow obtaining good results, but generally this condition would not exist and is not good policy. We do not believe such practice has been generally adopted. W. T. M., N. Y. ED. CO.

No. 123.—How far from a central station would it be practical to extend the Edison direct-current system, using the regular low voltage—110 or 220 volts—and where would it be desirable to install the alternating system?

One and one-quarter miles' radius; but the distance depends upon characteristics and extent of load.

W. S. BARSTOW.

We operate our Edison three-wire system for our inside lighting and power, and extend out about one and a half miles from our station with good results. We also have a throw-over switch, so as to cut out a large transformer during the daytime when our alternator is not running, and use our direct current on the secondaries for a large residence district, so that they can have the use of the current during the daytime. Outside of the direct-current district we use alternating current for lighting purposes; we start up about an hour before sundown and run until eight o'clock in the morning, excepting in dark and cloudy weather, when we run all day if necessary.

LA CROSSE GAS AND ELEC. CO.

Where the centre of distribution is not more than 3000 to 4000 feet from the station and where the distance from the station does not exceed two miles, we would, by all means, recommend the three-wire system, 110 and 220 volts, or 220 and 440 volts, if that has been proved to be satisfactory. We are operating on 110 and 220 volts and giving service night and day, both light and power, and find it far more satisfactory than the alternating system, which we displaced. We have found it necessary to make heavy investments in copper for feeders, but this investment is but little greater than the cost of transformers and secondaries would have been. During the peak of the load we have quite a heavy loss, but this is nothing in comparison with what the transformer loss would be. We are furnishing current for light, power and heating from one pair of machines and are giving our patrons very satisfactory service.

F. L. WILLIAMSON & CO.

This is entirely a question of local conditions; for instance, overhead or underground construction, density and character of lighting and power load, proximity of station to centre of load, etc., etc. In general, the alternating-current system will be preferable for residence and lighting territory and where there is very little probability of any demand for variable-speed motor work. When there is a demand for the latter, and in business districts having isolated plants, the direct-current system is a commercial and technical necessity. Ordinarily, it is not economical to transmit direct current at 230 volts more than 5000 to 6000 feet from station or substation, except as a temporary arrangement until territory is better developed. In some of the very largest cities it is sometimes advisable to install substations in such close proximity that at time of heavy load the distance of direct-current transmission from each is 3000 feet, or even less. At times of light load many of these substations are shut down, the direct-current switching arrangement being such that this can be done and a good pressure distribution be still maintained. P. JUNKERSFELD.

This would have to be figured out for each particular case. It would depend on the amount of load to be taken care of and also on whether the lines were overhead or underground; also on the class of business to be taken care of.

W. G. CARLTON.

This would depend a great deal on the character of the service, as to whether there were large motors on it or not. We have fixed approximately 4000 feet as the maximum distance to which it will be desirable to extend any Edison direct-current feeders.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

(*a*) In practice, not considerably over one mile in lightly-loaded districts.

(*b*) Where the yearly charges for direct-current distribution, including investment charges and operating cost for line, station machinery and line losses, materially exceed similar cost for the alternating-current system, the latter would be preferable on an equality of service requirements. P. T., N. Y. ED. CO.

No. 124.—Which would be more economical; to distribute on the alternating-current system, or to install a substation with rotary transformers?

This depends upon local conditions, load, etc.
W. S. BARSTOW.

This depends upon the system already in use. If a 60-cycle or higher frequency is used, there is no object in installing a rotary substation unless there is some special demand for direct current. The rotary substation with direct-current distribution would be much more expensive in most cases than a straight alternating distribution. W. G. CARLTON.

This would depend entirely on the amount of business you have. It would require a considerable amount of business to justify the installation of a substation. Of course, an important consideration, aside from the economic one, is that for certain purposes direct current would be very much superior.
THE EDISON ELEC. ILL'G CO. OF BOSTON.

The alternating current system of distribution is usually more economical from the standpoint of first cost and operating costs, but it has limitations in its applicability, depending upon the character of the service to be supplied.
P. T., N. Y. ED. CO.

No. 125.—Would there be any difference in the liability insurance rates as between the high and low-tension systems?

Liability insurance rates are usually higher on high-tension systems. W. S. BARSTOW.

Liability insurance companies charge higher rates for a high-tension than for the low-tension systems.
HOMER E. NIESZ.

The standard rates for liability insurance are the same for high and low-tension systems (over or under 550 volts) where the lines are entirely in subways; the rates being $1.80 for employees and $1.00 for the public—a total of $2.80. Where the lines are overhead the employees' rate is $1.80 for low-tension and $3.00 for high-tension; the rate for the public being the same in both cases, namely, $5.75.

H. M. E., N. Y. ED. CO.

No. 126.—How often should meters be tested?

Not less than once per year, and then before the fall load.

A. O. FRETZ.

We believe meters should be tested once every six months, and carefully cleaned and repaired.

WALTER L. MULLIGAN.

Once in 12 months. F. ELLWOOD SMITH.

The time varies. A new meter should be tested for light-load accuracy at least every six months until it is about two years old, after which it can be trusted for longer periods unless the service is hard. This applies to induction meters; the Thomson commutator type should be tested every six months.

C. C. GILES.

Meters should be tested once a year. However, if we make a proper analysis of our lost and unaccounted-for current each month, the comparative percentages of unaccounted-for current each month should guide us in this question.

H. H. SCOTT.

Every three months. W. S. BARSTOW.

We try to test our meters about once a year.

LA CROSSE GAS AND ELEC. CO.

Every six months. Inspect once in three months.

F. VAN der VOORT.

The type of meter and character of service will determine to some extent the length of time a meter may be left to operate without testing. Brush-type meters without adjustable shunts could profitably be tested every six months. A first-class induction meter should be tested about once a year. Meters operating under severe conditions of vibration, dirt, moisture, etc., should be tested oftener. If the meter readers are somewhat familiar with the operation of the meters, their monthly inspection may reduce the necessity of frequent tests.

P. A. BERTRAND.

As a general rule, meters should be tested annually, but under special conditions it is advisable to test them every six months, or even oftener, as:

When the meter is installed under very unfavorable physical conditions, due to dust or vibration.

When the meter runs for long hours under full load, causing more than ordinary wear, or

When special precautions in regard to accuracy are desirable, owing to the large consumption measured.

O. J. BUSHNELL.

We are following what we call our "discriminate method of testing," that is, basing the time between tests largely upon the work the meter is called upon to do, as shown by dial readings, or, in other words, the revolutions of the shaft upon its jewel, figuring that no meter should be allowed to make more than 1,000,000 revolutions without receiving attention. This means that some meters are tested every month, whereas others may go as long as nine or ten months.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

There are so many influencing conditions, that an inflexible rule can not be set. The type of meter has much to do with the interval between tests; direct-current meters of the motor type will be found to need more frequent tests and calibration than alternating-current induction meters. Capacity, use as indicated by the number of revolutions, vibration, and dirt, are also to be taken into consideration. Large companies are now testing *generally* on the yearly basis, with subdivisions according to the above at intervals of one month and upwards.

A. H. A., N. Y. ED. CO.

We have found that local conditions and the style of meter determine how often a meter should be tested. With a meter having light moving parts and in a residence district where there is practically no vibration, we assume that once in two years would be all that is necessary. In a business district or in a place where there is considerable vibration and the meter has very heavy moving parts, we should judge that it should be tested once in three months if accurate results are to be obtained. We do not believe that a fixed rule can be followed for all meters or conditions.

YOUNGSTOWN CONSOL. GAS AND ELEC. CO.

No. 127.—Should meters be tested in place, or should they be returned to the station for the purpose?

They should be returned to the station if possible, but can be tested very accurately in place by using portable indicating wattmeter and stop-watch. A. O. FRETZ.

Meters should be tested in place.

F. ELLWOOD SMITH.

We find it more satisfactory to test the meters wherever they may be installed. That prevents some of the liability of their being damaged while being carried to and fro.

WALTER L. MULLIGAN.

Our plant is not a large one, but we have found it more satisfactory to test our meters at our station rather than in place. GEO. B. LAUDER.

Meters should be tested in place.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

I believe it is good practice to partially test meters on the premises, and if the test should show that they are commercially out of calibration they should be taken to the station and thoroughly calibrated. We should not spend much time in testing or calibrating meters when installed, for this would cause distrust on the part of the consumer. If properly installed, I find them to be very reliable. (UNSIGNED.)

Meters should be returned to the station for testing. Conditions there are practically the same as where meters are installed and facilities for accurate testing are much better.

CHAS. H. PETERS.

It is usually better to test a meter in place, as a customer seems to have more confidence in a test made before his eyes than in one made elsewhere, even though he knows nothing about meters. It also takes less time. C. C. GILES.

We prefer to test meters where they are installed, as the conditions might be different in the station, or anywhere else. If found defective at the customer's place the meter should be carried to the station and results compared. We use meters that are sealed and send to the factory all such as do not come up to the requirements. S. S. INGMAN.

We believe that where possible meters should be tested in place, particularly when they are tested on complaint of a customer, and they should be returned to the station only when repairs are necessary. We make every effort to have customers present when testing their meters, as we find they are much better satisfied. WM. J. TROTT.

If we have any complaint, we test on the premises. In our annual test, part of the meters are tested in meter-room and part of them where they are installed.

LA CROSSE GAS AND ELEC. CO.

The only meter test excusable on a consumer's premises is one for complaint on high bill, and in the majority of cases this does not satisfy the consumer, for he does not understand the method of test, is prejudiced against wanting to know, and insists on changing the meter, no matter what the result of the test may be. H. H. SCOTT.

Meters should be tested in place. W. S. BARSTOW.

I am strongly in favor of testing meters in place instead of returning them to the station. By using a lamp bank properly wired up—which may easily be made portable—a range of load in one-watt steps can be obtained from one watt to 3000. This will cover a very large portion of the meters that are generally used, especially as the test on one-third to half load is as reliable as the test on full load for full-load accuracy of meters. The instruments that are used on tests can be kept as nearly correct for outside testing as for testing in the station. The test of meters in place is particularly valuable, as it ascertains the exact conditions and the degree of accuracy under which the meter is operated, and also gives the inspector an opportunity of discovering any irregularity in the service that might affect the registration of the meter. In other words, the meter tested in place is inspected for irregularities under the conditions under which it is operating, and is adjusted to register correctly under those conditions. The cost of testing meters in place is considerably less than testing them at the station, and does not require an extra stock of meters with which to make the changes.

P. A. BERTRAND.

In place, and under its particular operating conditions.

F. VAN der VOORT.

The more common practice is to test meters in place, which permits adjustment for electrical and physical conditions under which they are installed and destroys the possibility of their adjustment being changed in transportation and handling.

O. J. BUSHNELL.

Formerly it was the practice to return meters to the laboratory for the test, replacing same from the tested general stock. At present the large companies test the active meters in customers' premises, which results in confidence on the part of the customer in his metering device. By testing meters on customers' premises, accidental local conditions such as vibration, condition of use, etc., can be allowed for. The method is subject to criticism on account of error in wattage fluctuation, errors of instruments, personal errors, and a resultant accuracy less absolute. These variations, however, are usually within the limits assigned to generally accepted "commercial accuracy," and the system is therefore preferable.

A. H. A., N. Y. ED. CO.

Unless a test is intended as a demonstration to the consumer with his own particular conditions, we replace the meter with one from the laboratory with known condition, and return the older meter to the laboratory for testing and recalibrating. We adhere to this method for the reason that meters can be much more readily and accurately tested in the laboratory, the consumer has much less chance for suspecting something wrong, and the consumer is without a meter a very short time.

YOUNGSTOWN CONSOL. GAS AND ELEC. CO.

No. 128.—What degree of accuracy in a meter under test at five per cent of its rated load should be allowed to pass without further adjustment?

On such light load it is hardly practicable to adjust a meter closer than within five or six per cent. If the meter is adjusted as closely as this, care must be taken to see that it does not creep without load.
C. C. GILES.

Meters should be adjusted for the same accuracy on five-per-cent rated capacity as for any other per-cent capacity between the above and 50-per-cent overload. In other words, the meters should be correct within two or three per cent from five per cent of rated capacity to 150-per-cent rated capacity. We should discontinue the use of a meter that can not comply with this test, or install it in a place where it will not be likely to be subjected to loads at which we know in advance that it will be inaccurate.
H. H. SCOTT.

We allow all meters to pass that test within two per cent when tested at five per cent of rated load, without changing the adjustment of the meter.

LA CROSSE GAS AND ELEC. CO.

Two and one-half per cent.
W. S. BARSTOW.

A meter should be required to be within three per cent on range of load from five per of its capacity to 50-per-cent overload, and if necessary to adjust should be adjusted within two per cent within these ranges.
P. A. BERTRAND.

Two per cent fast or slow.
F. VAN der VOORT.

Meters of recent manufacture should be adjusted so that the error at five per cent of their rated capacity is less than five per cent.
O. J. BUSHNELL

Any error in excess of two per cent fast or five per cent slow we should consider required further adjustment. Whether or not better results than this could be obtained would depend somewhat on the type of meter.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The degree of accuracy at any load is subject to the laws of the state or other recognized authority as well as physical conditions. The tendency of most meters at this point is to run slow, especially if the meter has been in service any length of time, and, owing to this fact, the question resolves itself into a consideration of how much a company is willing to sacrifice. In the large industrial cities, there are conditions of vibration to contend with that make it impossible to obtain any accurate results at the five-per-cent load. The friction at this light load is of such a percentage as compared with the low torque that variations of five per cent and more at this load are not infrequent. It is generally conceded that under such conditions it is preferable to test at the 10-per-cent load, and an accuracy of two per cent plus or minus should be required at this point as well as on full load. A. H. A., N. Y. ED. CO.

No. 129.—What efforts, if any, have been made to introduce any form of prepayment meter?

We have used prepayment meters with good success, and find them a great advantage where it is hard to collect with others. WALTER L. MULLIGAN.

Several efforts have been made, but expense of meter has limited progress. W. S. BARSTOW.

The Chicago companies have in use about 150 prepayment meters. These are arranged for use with 10-cent pieces, and the current is sold on the basis of 20 cents per kw-hour. They are looked upon more as a pioneering device than as a basis for a permanent arrangement, and also as a way of getting business with people whose credit is bad and who will not put up a deposit. JOHN F. GILCHRIST.

We know of no effort being made in this neighborhood to introduce any form of prepayment meter.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Prepayment meters are made by at least two large manufacturing companies, representing types of direct-current and alternating-current meters, respectively. The device is subject to the criticisms of the regular type meter, and, additionally, to the inherent faults of the slot machine. Most consumers of electricity in the East prefer monthly bills, rather than the annoyance of attention to the device by both himself and the company's meter men. A. H. A., N. Y. ED. CO.

No. 130.—Is it good practice for central stations to furnish wattmeters free in small towns?

It is good practice. F. ELLWOOD SMITH.

Local conditions should govern this matter. We are in heavy competition with the enemy—the gas company—and we give our meters free, as a matter of policy. On general principles, I believe it tends to the popularity of the company to give as much free as possible. If a deposit for a meter can be obtained without kicking, all right, but I am a firm believer in the meter basis of charging, and advocate free meters if there is no other way. GEO. B. LAUDER.

We furnish wattmeters to our customers free of charge, but make a minimum charge for the service, so that about five months of the year our customers are paying for more than the actual current charge. In this way we get a certain amount of rent for our meters. We find this better than making a rent charge in addition to the current charge. S. S. INGMAN.

In this town of 5000 people, we furnish wattmeters, but charge a minimum rate of $1.00, and we think it pays, as many consumers would not pay for the meter, nor could they afford to pay a flat rate for all lights. C. P. WELLES.

Yes; but there should be a small minimum rate, say from $1.00 to $1.50, where less than this amount of current is used in one month. CHAS. H. PETERS.

In small towns, where meter rates are charged, I think it is always advisable to furnish wattmeters free of charge to all consumers. In this way only can the station manager be assured of first-class instruments on his lines, with the right to keep them in repair and in good condition at all times. Furnishing free meters is also conducive to increasing business.

C. W. HUMPHREY.

I would certainly not establish such a precedent. Small plants bear enough of the "white man's burden" without this feature. This applies to straight sliding-scale system. The Doherty rate would take care of meter rents.

GUY C. GUM.

Until the various types of wattmeters are sufficiently standardized so that the improvements will not require changes in installation every few years, as has been the case in the past, I would not advise any central station, large or small, to charge for electric meters. I believe that meters can be furnished by the central station and the cost of maintenance covered by a rental per month, or by additional price for current much more cheaply, and in a manner more satisfactory to the consumer, than would be the case if the meters were sold to the consumers.

P. A. BERTRAND.

Yes; the station should own the meter.

F. VAN der VOORT.

It is much more frequently to the advantage of the station than to the advantage of the customer that the customer should have a wattmeter, and it therefore seems a legitimate expense for the company to stand. JOHN F. GILCHRIST.

When we first started furnishing current by meter, we undertook to compel our patrons either to buy their meters or to pay a meter rental of $1.50 per annum. We collected the meter rent one year, but have not tried to do so since, as there was so much kicking about paying it that we thought it would be better to furnish the meters free, and have since done so.

F. L. WILLIAMSON & CO.

It is good practice in central stations to furnish wattmeters free in small towns. E. H. MATHER.

It is the generally approved custom in this country, and good practice indorses the furnishing of meters by the electricity-supplying company without charge, or as covered in the minimum monthly charge, in introduction of service and availability of electricity supply. A. H. A., N. Y. ED. CO.

No. 131.—What proportion of plants in the different states has adopted the inclosed-arc lamp for street service?

About two-thirds. W. S. BARSTOW.

The available statistics in connection with this point are very incomplete. The General Electric Company reports (February 25, 1902) that out of 1519 cities in 49 states and territories of the United States, 399—or over 25 per cent—have adopted the series inclosed-arc lamp for street lighting. From statistics obtained by me in March, 1903, from 30 cities in 16 states, it is interesting to note that whereas only a few years ago most of these cities were lighted by open-arc lamps, at the present time series direct-current inclosed-arc lamps are used for street service in five of them, series alternating inclosed in three, and multiple direct-current inclosed in three.

During the past year the inclosed arc has made great inroads on the open for street illumination, and, so far as I am aware, the only extension of open-arc-lamp installation for street service has been in the form of additions to some of the existing high-tension open-arc circuits. The new plants installed have invariably adopted the inclosed arc.

LOUIS B. MARKS.

It is my opinion that from 28 to 30 per cent of the plants in the different states have adopted the inclosed-arc lamp for street service. In this connection, you may be interested to know that when considering the cities in the different states having a population of 25,000 or more, there are 60 per cent of the plants that have adopted inclosed-arc lamps for street lighting.

H. W. HILLMAN.

From 60 to 70 per cent of the street lamps are inclosed arcs.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 132.—Is it the best practice to omit outer globes of inclosed-arc lamps for street lighting, provided the inner globe is protected from the weather by a metallic shade, the same as usual when outer globe is used?

No; for the outer globe will prevent insects from getting in; will also give a better vacuum in inner globe, and will keep the temperature of inner globe more uniform; all of which will help to lessen the breakage of globes. A. O. FRETZ.

We have thirty-seven 5.5-ampere, 74-volt, series alternating, 60-cycle inclosed-arc lamps, with inner globe, but no outer. Lamps are operated until 12 o'clock, moonlight schedule and dark nights. The breakage for 18 months preceding February 13, 1903, was four clear inner globes per lamp per year. These lamps have the usual metal shade, but no outer globe.

Four clear inner globes at 15 cents, delivered......	$.60
Saving one outer globe per lamp per year at 50 cents..	.50
Equivalent net cost of inner globes per lamp per year if outer globes had been used, or an average of two-thirds of one inner globe per lamp per year..	$.10

Our experience, and, so far as our knowledge goes, the experience of others, is that one outer globe for each inclosed-arc lamp per year is about the average life of these outer globes; we believe that very few plants, large or small, can show so low an average breakage as two-thirds of one inner globe per lamp per year.

The saving in labor is not reckoned in the above. A trimmer can easily handle 10 per cent more lamps where outer globes are omitted. There is also a gain of 10 per cent more light on the streets where outer globes are not used. In view of these facts, we unhesitatingly say that it does pay to leave off outer globes under these conditions. H. A. SPRAGUE.

We have used street lamps without any outer globe and have got along all right so far as breakage is concerned. It seems universal to use outer globes, however, and on that account it is probably better practice to do so.

GEO. B. LAUDER.

It is not good practice to omit outer globes. No hood or metal shade can be applied that will keep the elements from contact with the inner globe unless said shade is several feet in diameter or extends below lower carbon holder. Cold air in contact with the inner globe transforms it into a condenser, or still, and greatly assists in the precipitation of both gases and grayish white deposit. GUY C. GUM.

The best practice is to use outer globe as well as inner globe for street arc lighting with inclosed-arc lamps.

W. S. BARSTOW.

We do not think it is a good practice to omit outer globes. We know of no metallic shade that will protect the inner globe in wet weather.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The outer globe in general use for street lighting is of clear glass and absorbs about 10 per cent of the total candle-power. Without the globe the loss in diffusion would greatly offset the gain in candle-power; again, that would be confined to a comparatively small area beneath the arc lamp.

S. G. R., N. Y. ED. CO.

No. 133.—Is there any known remedy for the humming of multiple alternating-current arc lamps?

Use spring suspension with rubber buffers, to prevent humming of multiple alternating-current arc lamps becoming noticeable, if used on frequencies of over 60 cycles.

W. S. BARSTOW.

Support lamp by means of a lead ring or loop.

EDITOR.

A properly-made and fitted gas cap is the best anti-hummer extant. Nine-tenths of the humming in an alternating-current lamp is produced at the arc through improper inclosure. A slight tipping of the globe will show this. Loose, laminated construction is also prone to set up a howl, and can be somewhat eliminated by wedging. Patents control the gas-cap question. GUY C. GUM.

The humming of alternating-current arc lamps is inherent in the arc, but in a well-built lamp operated under favorable conditions it may be reduced to such an extent as to be unobjectionable in most cases of commercial service. The hum of the arc itself is often much less than the noise due to the vibrations of the lamp mechanism. The latter evil may be largely overcome by proper design and construction of the regulator. The lamps should always be hung from elastic supports. The noise of the arc may be diminished by suitably inclosing the arc, and quite overcome if the lamp be operated at fairly high frequency. Under commercial conditions on existing circuits, however, the humming of even the best alternating-current lamps is more or less audible, and no means have yet been devised of entirely overcoming the noise. LOUIS B. MARKS.

We do not quite understand the question as asked. It is, of course, impossible to eliminate the humming entirely. It may be somewhat reduced by putting a rubber cushion, or some such device, on the hook on which the lamp is hung and by keeping the various parts of the lamp tight and free from vibration. Of course the humming and the arcing would not be affected by any of these devices.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

None in commercial use. Inner globes and outer globes closely fitting into or against spring holders under tension serve to confine humming. Securely fastening by soldering or welding the screws and rigid sections of the lamp mechanism, also serves to decrease noise from vibration.

S. G. R., N. Y. ED. CO.

I would suggest inclosing the arc and tightening or cushioning any loose parts of lamp that may vibrate.

GEO. D. SHEPARDSON.

No. 134—Is it desirable, from the electric-light company's standpoint, to advise the use of the so-called "turn-down" lamps by consumers? Will the advantage of advertising to the general public offset the corresponding loss of current due to the fact that the majority of meters in use will not register on the small filament on turn-down lamps?

We have found it good practice to introduce the turn-down lamps to our customers. They find the arrangement very convenient, and are inclined to use light in other places than where they wire up for the connection.

WALTER L. MULLIGAN.

We advocate the use of turn-down lamps by our customers, and are strongly in favor of their use. Our idea is that electric lighting is popular on account of its convenience, as much as anything else, and this feature is certainly a long step in that direction. We have secured several residence customers on the strength of the turn-down lamp. We have no trouble with our meters failing to register current consumed by the turn-down lamps, but if the meter did not register the current, we should still advocate the use of the lamp for the reason stated. What we might lose in current would be more than made up to us in satisfied customers. S. S. INGMAN.

We believe that it is desirable to encourage the use of the turn-down lamps by consumers. While it is true that they do not register on the majority of meters on the small filament, it is also true that they use but a small quantity of current, and the convenience to the consumer is a good advertisement.

CHARLES G. BILL.

Yes, to both questions. The current lost is a very small item, and most of the lights would not be burned if a lamp of higher candle-power had to be used. We find that most of our meters will run on turn-down lamps. C. C. GILES.

We do not advise the use of any lamp that does not consume at least 20 watts.

LA CROSSE GAS AND ELECTRIC CO.

Yes. W. S. BARSTOW.

We believe it is not desirable.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

We are putting out turn-down lamps at cost, hoping that the extra takers, etc., will more than pay us for loss of current.

FRED. B. HUBBELL.

Turn-down lamps are a novelty and a convenience that appeal greatly to the customer, and are undoubtedly a great factor in securing residence business. The writer believes that any unregistered current that they may use is more than compensated for by the good they are doing to the electrical business in an advertising way. JOHN F. GILCHRIST.

We consider it advisable to give our customers the benefit of turn-down lamps, as we find that it is such things as this that make electric lights almost indispensable, and in this way we increase our business far more than the reduction in the amount of current used would amount to.

F. L. WILLIAMSON & CO.

It seems desirable for an electric-light company to provide every possible convenience to its customers. One of the disadvantages of the electric light has been that it is either all on or all off. The turn-down lamps of various types, and regulating switches containing resistances, are desirable conveniences, and it would seem that their use should be encouraged by the supplying companies, upon whom should rest the responsibility of providing a meter sensitive enough to record all of the current they sell. A. W., N. Y. ED. CO.

In my opinion, electric lighting should be made as flexible as any other illuminant in respect to being regulated and dimmed as occasion requires. "Turn-down" lamps, in providing an economical means of accomplishing this, unquestionably aid electric lighting and enable central stations to compete with gas and oil, both of which can be turned down. The objection that there is some current lost through the meter failing to register on the small filament of the turn-down lamp, is not a material one, as this loss amounts to but little, and it can be readily discounted by the advantages gained in having customers use electric light generally instead of adopting gas where a dim light is required. FRANCIS W. WILLCOX.

No. 135.—What system is mostly used to check up lamp manufacturers' guaranteed life and general efficiency?

We test 25 per cent of the lamps received for initial candlepower and efficiency, and run frequent life-tests.

WALTER L. MULLIGAN.

We know of no system of checking lamp manufacturers' guarantees so comprehensive and so generally useful as the system of the Lamp Testing Bureau. This system, roughly stated, is as follows:

On small purchases of lamps the packages are sent by the manufacturer under orders from the purchaser to the laboratory of Lamp Testing Bureau (on large purchases we go to the factory of the lamp manufacturer), where they are submitted to a very careful inspection to determine the number of lamps having faults due to careless inspection by the manufacturer. This requires a knowledge of factory faults, and requires apparatus for detection of lamps having bad vacuum and "spotted" or weak filaments. A sufficient number of lamps, selected at random, are then run through a photometer, where the candle-power and amperes are measured. By agreement between the purchaser and the manufacturer, certain variations from the standard candle-power and the standard amperes are allowed, but the lamps falling outside the limits of variation prescribed are rejected, and the entire barrel is sent back to the manufacturer. Not only must the individual lamps measure within the specified limits of candle-power and amperes, but the average candle-power and the average amperes must fall within certain prescribed limits.

These inspections and tests determine whether or not the lamps are acceptable by the purchaser, and if acceptable, certain sample lamps are selected—either at random, or in accordance with previous arrangements between the manufacturer and the purchaser—and these selected lamps are set up for continuous burning on test banks, run at extremely close voltage regulation, and their performance through life is noted; first by putting the lamps into a photometer periodically—preferably after 50 hours' burning and thereafter at each 100 hours of burning—and a candle-power performance curve plotted for each lamp. From this curve can be determined the candle-hours of actual service rendered by the lamp. This is a true measure of the value of the lamp, as it shows what the lamp is capable of when operated correctly. It is easy to determine what this same lamp would do if operated a trifle high or a trifle low as to voltage; but unless the average voltage of the customer is known, it can not be accurately stated what performance that customer might expect from these lamps in service on his circuit.

While undergoing this candle-hour test, various faults in the lamp are noted. A good average record can be made of lamps some of which are very poor and some of which are very good indeed, but the best lamps are those whose average value is high and which are uniformly good, none being very bad and none exceptionally good. Those lamps that fail very early in their life give cause for severe complaint on the part of customers, and their badness is not compensated for by the exceptionally good lamps from the same barrel.

WILSON S. HOWELL.

We depend upon the Edison Lamp Bureau. A large number of the smaller concerns probably do nothing to check, though a great many of them have their own photometer rooms.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The general efficiency and life of incandescent lamps may be ascertained by the use of a photometer and life-test board. Ten lamps selected from each barrel received are tested for candle-power and watt consumption at their labeled voltages. A sufficient number of these to represent the average of the lot are then placed on the life-test board. The board may be equipped with resistance so that the average voltage on the lamps is about the same as that at which they are rated. Accurate results, of course, require means for maintaining constant pressure, but this method is nevertheless very satisfactory as a means of ascertaining the comparative life of the lamps of different makes under existing conditions.

H. B. GEAR.

A comprehensive system that has met with general approval, both on the part of the manufacturer and the purchaser, is that originally inaugurated under the auspices of the Association of Edison Illuminating Companies under a schedule of inspections and tests covering all the qualities of the lamp product, mechanical, electrical and photometric ; these tests being carried out by a third party (in this case the Lamp Testing Bureau), acceptable to the manufacturer and purchaser and provided with special facilities for the maintenance of correct standards and adequate testing facilities.

T. W. V., N. Y. ED. CO.

Lamp manufacturers' guarantees cover two points: (1) Correctness of initial limits; (2) Life and candle-power performance. The general practice in checking up limits (1) is simply to test each lot or barrel received and reject such packages as fail to conform to the limits guaranteed. The customer can always elect to test the entire barrel and reject only such lamps as fall outside the limits, and this method is sometimes adopted when the lamp stock is low and it is not desirable to return all the lamps in the package or box, but simply those that are not up to specifications.

For requirement (2)—life and candle-power performance—the general method is to take one or more lamps from each package or shipment and place these lamps on life test with lamps from other lots, observing the proper precautions as to correct voltage, efficiency, etc., to insure a definite result.

The writer has found that customers while checking up manufacturers' guarantees on limits quite frequently omit to check up the guarantees on life and candle-power performance. This, it should not be necessary to point out, is a mistake, inasmuch as the correctness in initial limits does not mean the quality, and of the two specification features it is more important to check up life and candle-power performance than initial limits. It should be evident to every one that specifications without checking tests are worthless.

FRANCIS W. WILLCOX.

No. 136.—What is the best incandescent-lamp base to adopt, and why?

Screw or Edison base. Contact is better. A. O. FRETZ.

We believe in the Edison base. Probably more of this kind of base are in use in this country than of any other kind. This would seem a good reason for its adoption.

GEO. B. LAUDER.

I have used a number of makes of incandescent lamps, and I like the Edison base better than any other. In putting in the lamps you are not likely to short-circuit the line, or in any way give trouble, and it is seldom that they pull out of their sockets.

(UNSIGNED.)

The Edison, because the lamps are held firmly in the socket, making a sure contact, and the lamps are cheaper with this base than with almost any other. C. C. GILES.

Edison base, as it is mechanically strong.
W. S. BARSTOW.

The Edison base, because it is standard.
LA CROSSE GAS AND ELECTRIC CO.

We have recently put in Edison to replace those we formerly used, mainly because the lamps are cheaper, and to secure uniformity. FRED. B. HUBBELL.

The Edison base, on account of saving in cost, and superiority of mechanical design, allowing of neater and stronger construction with fewer parts and better fastening of connections; one of the main objections to the Thomson-Houston base being the trouble experienced from loosening of wires from contacts in face of base. P. G. GOSSLER.

We believe the Edison base is the best, because it is the cheapest and, mechanically, the most simple and substantial.
THE EDISON ELEC. ILL'G CO. OF BOSTON.

The Edison base. It is estimated that probably three-fourths or more of all the sockets in use are of the Edison base type, and consequently lamps with Edison bases are carried in stock by every lampmaker in larger quantities, more voltages, more candle-powers and efficiencies, than lamps with any other type of base. This means that the Edison type of base holds the lamp firmly in its socket and by the action of screwing-in is compressed into it. Other types of screw base are dragged into the socket, with a tendency to pull it apart. Other bases are held by springs and clips rather insecurely and do not make as good contact as the screw-type base.
T. W. V., N. Y. ED. CO.

The Edison base, because it has the most perfect mechanical and electrical contact, without undue expense and need of careful handling.
YOUNGSTOWN CONSOL. GAS AND ELEC. CO.

The Edison base deserves credit for being the best base. First, because it is most universal. Second, because it has fewer undesirable features than any other base. Third, it is simple. The lamp screws home without any effort and no live contacts are exposed in the latest form of lamp base. I think the strongest argument in favor of the adoption of the Edison base as a standard is the fact that fully 95 per cent of all the installations made in the United States are Edison base. It may, therefore, be considered as a universally accepted standard. I think lamp dealers consider all other bases as special, and do not carry them in stock.

I believe that every one agrees that the Westinghouse is a poor type of base and should not be considered. Comparisons can, therefore, be drawn only between the Thomson-Houston and Edison bases. The Thomson-Houston base costs the average customer one cent more per lamp than does the Edison base lamp. It is only a semi-standard base, so far as we are concerned, as we do not carry lamps in stock with the Thomson-Houston base except on future delivery orders.

As to the mechanical qualities, I think the Edison base is superior in every respect. It has also the advantage of being comparatively waterproof. FRANCIS W. WILLCOX.

No. 137.—In the latest type of Edison lamp there is no place suitable for stamping the date of delivery to customers when free renewals are furnished. Would it not be advisable for the manufacturers to have blank labels pasted on for this purpose?

In my opinion, yes. A. O. FRETZ.

It would probably be better for each central station that practices dating its lamps, to supply its own labels and affix them to the lamps, using a date stamp. As it is not a universal practice for central stations to date their lamps, it would not be desirable to ask the manufacturer to provide labels that could be more readily supplied by each company, as above suggested. In the light of present practice (the periodic renewal of lamps regularly maintained), it would seem that the matter of dating lamps was rather an out-of-date practice, and that instead of wasting time and labor in this way it would be better practice to renew the lamps periodically on any one of the approved systems in use to-day. FRANCIS W. WILLCOX.

We think it would be advisable to have a blank label pasted on lamps, so that date of delivery could be stamped on.

LA CROSSE GAS AND ELECTRIC CO.

Blank labels would be washed or scraped off by the consumer while cleaning lamps. Can not the date be scratched on the base or cap of lamp? GUY C. GUM.

I see no advantage in stamping date of delivery to customers on lamps. The length of time the lamp is on the circuit does not affect its life; it is only affected by the number of hours it is used, and the date would in no way tell how long this use has been. Up to a few years ago we stamped our lamps, but have now abandoned the practice. T. RICHARDSON.

Yes.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

We believe that so few users of lamps have a proper system of dating renewals that the extra label on lamps should not be applied except upon special request from those few purchasers. Paper labels are a disfigurement to the lamps, especially when soiled ; it is better to etch a label upon the lamp. This is both permanent and neat, and does not interfere with the illumination; the etching of the date can be done by a cheap man in the lamp-room with a rubber stamp and the proper kind of acid.

T. W. V., N. Y. ED. CO.

No. 138.—What has been the experience with electric heating in a small way?

We have been having considerable experience with electric heaters during the past season, and find that they give very satisfactory results at the price we make—five cents per kw-hour. WALTER L. MULLIGAN.

Electric heating is economical only when used for special purposes, where other methods can not be used.

W. S. BARSTOW.

Electric heating is making slow progress. It is perhaps more expensive than oil or gas, but it possesses the feature of convenience far beyond that of any other method. The absence of odor is also an important consideration. It has been found that gas heating causes a considerable feeling of depression—or oppression—mental or physical—placing a limit upon the work of the occupants of offices so heated. These objections can be entirely removed by installing the electrical system. Notwithstanding the advantages, the growth is slow—the New York increase of the year being approximately from 300 to 400 separate pieces of heating apparatus.

A. W., N. Y. ED. CO.

No. 139.—What has been the experience in operating single-phase motors on lighting circuits?

We have several single-phase motors on our lighting circuits, one of which is 10-hp, and while we find it causes a slight fluctuation on the lighting circuit, it is only run in the daytime, and as the load from the motor overlaps the lighting circuit but three months in the year, we do not consider it serious enough to be objectionable.
S. S. INGMAN.

Whether satisfactory or not depends upon the size of generator or generators, line and transformers to which it is connected, the starting current referred to same, and the character of the load.
PEORIA GAS AND ELECTRIC CO.

Single-phase motors can be used on lighting circuits without any difficulty if their load is steady. If it is irregular, they should be connected to transformers having a capacity at least double that of the motor, or, preferably, to independent transformers. They should not be used where it is necessary to start and stop frequently.
C. C. GILES.

It has been successful with us; we have about 150 horsepower in use.
F. VAN der VOORT.

Single-phase motors are being operated in large numbers on lighting circuits in Chicago without interfering with the lighting service. These motors are operated on separate transformers.
H. B. GEAR.

Perfect success has been experienced in operating single-phase motors on alternating-current circuits when existing conditions are considered and motors installed properly with reference to those conditions. The use of a form of starting resistance is advised when comparatively large loads are to be started, as being the best method to avoid fluctuations in the lighting service.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The Missouri-Edison Electric Co. is now operating on lighting circuits a connected load of about 1200 horse-power in alternating-current, single-phase, 60-cycle motors. The motors range in size from small fan motors up to 30-hp. The results have been satisfactory. We find it is necessary to limit the starting current by starting the large motors on half voltage, or on a rheostat. We also use separate transformers for large motors in our overhead district. In our underground district, motors are connected to secondary service direct.

M. L. HOLMAN.

It is the general experience of stations operating units of several hundred kilowatts (300-400) that single-phase inductive motors of 5-hp or less can be successfully operated by making the copper in the lighting circuits sufficiently heavy not to cause bad drop when the motors are started.

W. T. M., N. Y. ED. CO.

Our experience in the operation of single-phase motors has been entirely satisfactory, and we shall continue our present method of having them installed wherever possible.

YOUNGSTOWN CONSOL. GAS AND ELEC. CO.

No. 140.—To what sizes is the operation of single-phase motors on lighting circuits practically limited?

About 15 horse-power, if started frequently.

F. VAN der VOORT.

The limit of size of single-phase motors on lighting circuits is practically determined in most cases by the generator capacity. The drop due to the starting of single-phase motors larger than 3-hp on a 100-kw machine is usually sufficient to cause a momentary dip in the pressure. This effect is more noticeable when the machine is carrying a comparatively light load. In Chicago, where the smallest machine operating such motors is of 400-kw capacity, and where three-phase service is provided for larger motors, the size of single-phase motors is limited to 5-hp. The line drop due to motors on a 2200-volt circuit has little effect on the pressure delivered to other transformers on the same circuit where the motors are within three miles of the station. H. B. GEAR.

Single-phase motors of 3-hp on circuits of small capacity, and motors of 5-hp on circuits of generous copper capacity, have proved to be the maximum sizes that can be installed and started in the ordinary way without affecting the lighting service, but these sizes can be somewhat increased by using some device to limit the starting currents, as, for instance, a resistance box. The introduction of automatic feeder regulators on circuits operating motors and lights will materially improve present conditions.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The size of single-phase motors that can be operated satisfactorily on a lighting circuit is limited by the capacity of the circuit, the character of the lighting load, and the ability of the manufacturers to build the motors. The Missouri Edison Electric Co. is operating a connected load of 55 horse-power on a circuit of 100-kw capacity. A larger variation of voltage can be permitted on a lighting circuit in a manufacturing district than on a circuit in a high-class residence district or a commercial district. M. L. HOLMAN.

(The recording voltmeter chart inclosed with Mr. Holman's answer shows almost perfect regulation.—EDITOR.)

The stations, as spoken of in answer to question 139, could not run satisfactorily larger single-phase induction motors than 5-hp, as the drop on the 300-kw generators would be excessive if larger motors were used. Stations with heavier circuits and larger generators could probably run proportionately larger motors. W. T. M., N. Y. ED. CO.

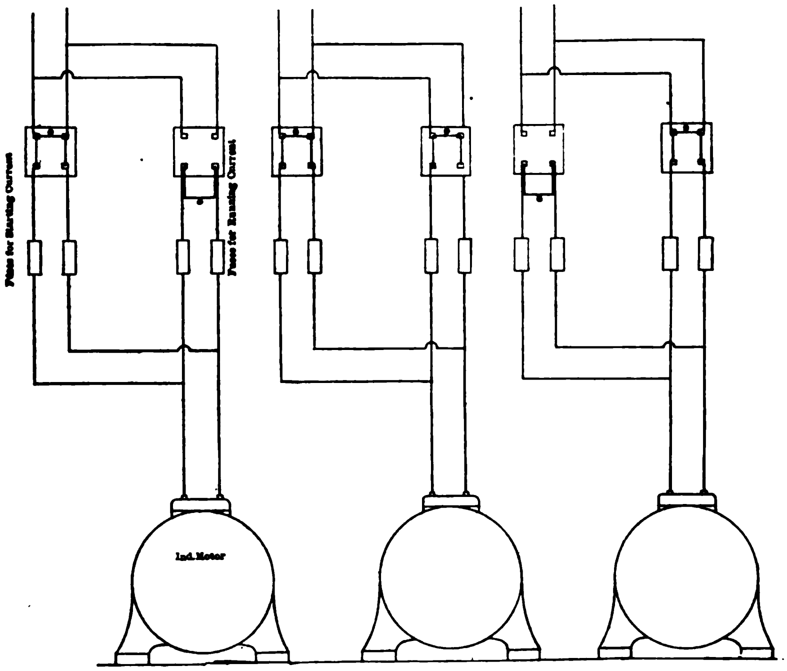
We have found the operation of single-phase motors limited only to the sizes in which they are manufactured. In another station, however, the equipment in generators and transformers might limit the size of single-phase motors that could be used. This would apply, however, to all classes of induction motors.

YOUNGSTOWN CONSOL. GAS AND ELEC. CO.

No. 141.—What is the best method to pursue where the starting current of an induction motor is so far in excess of the running current that a fuse which will hold the starting current will not protect the motor?

We know of nothing to do except to fuse the motor heavily enough, or use a circuit-breaker heavy enough to start the motor and let it go at that. We have thought this over a good many times, but have arrived at no results. GEO. B. LAUDER.

The best method is to use a two-switch and double-fuse arrangement, using a heavy fuse for the starting current and the proper size of fuse to protect the motor for the running current. The arrangement is best shown by the accompanying sketch. It adds very little to the cost of installation, and does not require more than 30 seconds' additional time in starting the motor. A. C. BLINN.



Use time-limit devices. W. S. BARSTOW.

Use a double-throw switch that will allow the motor to be started and attain full speed without the fuse in circuit, and then be thrown to running position with fuses protecting. A much better device is a circuit-breaker arranged to be locked during starting period and to be released when motor attains full speed, with an adjustment suitable for protection from abnormal currents in the running position.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The question evidently refers to an induction motor that does not use a starting resistance in series with the armature winding. Such motors are usually started through the means of so-called "auto-transformers" or "starting compensators," which reduce the voltage to the minimum that will give the required starting torque. Notwithstanding this reduction in voltage, the starting current is usually several times the running current, so the question still remains unanswered. One very satisfactory way of overcoming this difficulty is to so construct the switch used in connection with the starting compensator that the fuses will be out of circuit when the switch is in the starting position but will be thrown into circuit as soon as the switch is in the running position. While something may happen requiring the opening of the circuit during the few seconds that the fuses are out of circuit, the attendant is always on hand at such a time and can immediately break the circuit with the switch.

WALTER S. MOODY.

No. 142.—What is the best method of operating electric elevators on an alternating-current system; one, two or three-phase?

Three-phase. W. S. BARSTOW.

Single-phase, belted. F. VAN der VOORT.

The phase makes but little difference, but to get good, reliable results, the instruments (including the brake) for controlling the motor should be supplied with direct current from a rotary transformer or aluminum cells. G. A. LE FEVRE.

Absolutely no choice.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The writer knows of no satisfactory single-phase motor that can be directly connected for elevator service as generally required. With reference to two or three-phase motors, it is a question of distribution, as a two-phase motor will do the work equally as well as a three-phase. W. E. McC., N. Y. ED. CO.

No. 143.—What has been the experience of small lighting plants that are furnishing current for electrically-driven pumps in city waterworks? Has it been found to be profitable?

The writer has had a personal encounter with a 75-hp, three-phase induction motor, direct-connected to a 1,000,000-gallon triplex, double-acting pump, working against a head of 110 pounds' pressure with a lift of 10 feet and controlled from the electric-power station, a distance of two miles.

Most of the lighting companies are handicapped with a three-hour peak every 24 hours. To take care of this peak, it is necessary to install sufficient apparatus, which lies idle for at least 18 hours, bringing in no revenue whatever. In fact, every piece of apparatus in the station is operating at its lowest efficiency. We will suppose that an arrangement could be made with the company supplying the city with water where it is necessary to use a pump having the equipment and a reservoir large enough to keep a supply of water for at least 10 or 12 hours ahead of the demand. Controlling the equipment from the central station, you will soon discover that you can dispose of current for this purpose at an exceedingly low figure, and at the same time show a decided decrease in cost of manufacturing per kw-hour and have a proportionate increase in revenue.

Taking the following as a base to work upon, I would say that electrically-driven pumps operated from a central station can be operated with economy to both producer and consumer.

After selecting a pump that exactly suits the conditions under which it will operate, provide it with a by-pass of sufficient capacity to take the entire discharge of the pump, automatically controlled so that the pressure will at no time exceed the capacity of the pump. Arrange to operate the equipment during the light-load period, controlling the supply of current from the central station. Assuming that the height of the reservoir is 256 feet, the capacity of the pump at one revolution is 15.7 gallons, and that the speed is 40 revolutions per minute, you will require 40 horse-power to operate this pump against the given head at five pounds of coal per hp-hour. In 24 hours you will have used 4800 pounds of coal, which at $2.50 per ton costs $6.00; two firemen at $2.00 each makes a total of $10. Most pumping stations are located where it is necessary to haul the fuel; this, of course, would be an additional expense. Ten dollars represents the cost of pumping per 1,000,000, or one cent per 1000, gallons.

An electric equipment performing this same work will require, including line loss up to two miles, 717 kilowatts per 1,000,000 gallons, or .00716 cent per 1000; which current, if disposed of at the mill of the manufacturer, can in most instances be sold for one cent per kw-hour, provided the consumer installs the transmission line. Of course this pump will require some attention, but this can be arranged with a lamp trimmer, or some one connected with the company who may reside in the immediate neighborhood of the station.

From my experience I would suggest that the series-wound motor is especially adapted to pumping water, and that where an alternating motor is necessary, one with collecting rings be installed, with a compensating device to take care of the variable conditions of pressure. The service on the average pipe line is similar to the demands of a trolley road, and absolutely requires a degree of flexibility that is impossible with an induction motor. I would further suggest that if it is necessary to install an induction motor, the pump and the motor connected to it be of the same relative horse-power, instead of the motor having a greater horse-power capacity than the pump. With proper installation, which must be carefully designed to suit the local conditions, there is no question about the economy of electrically-driven pumps where current can be obtained at a moderate charge. H. M. BEUGLER.

The experience of the Crookston Water Works, Light and Power Co., in operating city water-works plant, electrically driven, has been very satisfactory. Our pumps are operated in connection with an overhead tank, which has sufficient capacity to supply consumption during evening peaks of lighting load. The plant can then be used its full capacity for lighting, and when the peak is passed the pumps are started and run as occasion demands, the tank having to be filled for next evening's peak. In this way, it helps straighten out the load curve of our station.

The pumping station is located 1300 feet from the power-house; the motor-starting box is in the power-house and the pump is started from there. A pressure gauge, arranged to show the stage of water in the tank, is placed on the switch-board under the eye of the attendant, enabling him to know at any time what water is in the tank. The pumps can be so arranged by using foot-valves or other devices that they will be self-priming, and by the use of self-oiling bearings on motor and pumps the attendance is reduced to a minimum. Our station attendant examines the pump and motor once a day, and we have found this to be sufficient during the four years that we have operated electrically-driven pumps. We have practically no labor charge for the pumping-plant operation.

The best way to contract for service of this kind is to charge by the gallons pumped. Measurement can be agreed on either by piston displacement or by meter installation in delivery pipe. Pumping into a tank 100 feet high would ordinarily cost .75 cent per 1000 gallons, counting fuel, attendance and oil for pump, and counting the efficiency from the engine pulley to discharge end of the pump, or to discharge into tank or stand-pipe, as 50 per cent. The cost to a small town for a steam-driven pumping plant, including fuel, attendance, etc., will easily reach two cents per 1000 gallons. Assuming a consumption of 250,000 gallons per day, at two cents per 1000 it would amount to $5 00. The cost of pumping 250,000 gallons at .75 cent equals $1.88. Profit to station per pay is $3.12, which for 365 days makes $1138.80.

The city having its pumping plant of 250,000 gallons per day operated for $1825 per year will feel that it has made a good bargain, particularly if it has had experience in operating a steam-driven plant for some years. An electric-light plant undertaking to pump the city's water will feel that it is making a nice profit on its investment. In fact, a very small investment will often be sufficient, as the city can be made to buy its own motor, and the service lines of the lighting plant may run close to the premises, making no additional investment in copper necessary. Wherever conditions are reasonably favorable, the operation of electrically-driven water-works pumps will be found profitable to the lighting plant and very satisfactory to the town receiving the service.

ED. PETERSON.

No. 144.—Would it pay to operate a single-phase 5-hp motor for pumping, to replace a steam pump that is run for an independent boiler requiring a man in attendance? Company that owns pump, owns lighting plant.

The conditions appear to be very favorable for a motor.

C. C. GILES.

We should say that it certainly would pay to replace the steam pump with a motor-driven pump.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 145. – What is the best method of preventing or mitigating the bad odor from exhaust steam used for heating purposes?

The bad odor is due to the escape of air or steam from the radiators, usually at the air vent, and may be prevented by piping the air vents to the outside of the house or attaching them to an exhauster or vacuum system similar to the Paul.

PEORIA GAS AND ELECTRIC CO.

We have had very little complaint of bad odor from exhaust steam, and do not think it worth while to cure the smell, even if it could be done, which seems impossible, as it prevents customers from letting the steam waste. C. P. WELLES.

Carry sufficient back pressure on the engine to circulate the exhaust through the heaters and return the drips to a tank or the sewer. If the full volume of exhaust passes through the heaters the drips should be returned to the tank and an atmospheric outlet be provided at the end of the line similar to the regular exhaust head. W. I. D., N. Y. ED. CO.

No. 146.—Which is the better system to use for street lighting in small towns of 1500 to 3500 population; the multiple alternating arc or the series alternating arc, and why?

Multiple; because of flexibility. One light or more can be added without adding "tub transformer," or without having to refer to the load on the street circuit. Individual arc-lamp transformers are now made so that the efficiency compares favorably with that of the constant-current transformers.

GEORGE L. COLGATE.

I would say that, as a general thing, the smaller the town, the more seems to be expected from an arc light; the consequence being that they are placed long distances apart. If the multiple system is used, each light must have a separate transformer, or if several lights a considerable distance apart are placed on one transformer, the cost for copper will be high. The lights can not be turned off at the station unless a third wire is used, without turning off the commercial lights at the same time, provided the same circuit is used for both, and if it is not, then I can see no good reason for using multiple arcs for street lighting except as a temporary expedient. Where it has been decided to use alternating current for street lighting, the series system should be the one adopted, the current being supplied through a regulator or by a constant-current transformer. Only one wire is required—usually No. 6—and the circuit is controlled from the station. This system has long passed the experimental stage and has proved to be reliable, flexible and convenient. W. R. GARDENER.

For street lighting in a small town of 1500 to 3500 population, the floating-coil alternating-series system is, in my opinion, the best, on account of its low first cost and ease of handling, and also on account of the series arc giving so much less trouble in starting and very much smaller percentage of outs.

G. B. LELAND.

Series arc. Better efficiency and cheaper.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

For street lighting in small towns of 1500 to 3500 population the series alternating arc is the best system to adopt, for the following reasons:

(*a*) The amount of copper in the line construction is less than with a multiple system.

(*b*) The method of lighting and extinguishing a series system is very simple and can be done from the generating station.

(*c*) The number of "outs" is less in the series system than in the multiple system. E. H. MATHER.

No. 147.—What would be the best system for a central station to adopt for reaching a town five miles away from station, with a load of about 30 kilowatts on primary for lighting purposes? The station *is equipped with two-phase, 60-cycle, 2200-volt alternators. Should a line be run from station at generator voltage, or should step-up transformers be used?*

At generator voltage. GEORGE L. COLGATE.

I should say that a three-wire circuit, run from station at generator voltage, will give satisfactory service. It will be found advantageous to have a small substation at the point of distribution, where the load can be divided into two or more circuits, so as to balance the load conveniently; also so that in case of trouble only a part of the service will be interfered with. W. R. GARDENER.

A central station desiring to operate a load of 30 kilowatts at a distance of five miles from the station having two-phase 2200-volt generators, should build a line of two No. 4 wires that would operate at 2200 volts without step-up transformers. This would give a loss of 10 per cent at maximum load, but would involve a smaller investment than would a line of No. 6 wire operated at high pressure with step-up and step-down transformers, and would save step-up transformer losses.

H. B. GEAR.

Generator voltage.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 148.—In power-transmission plants operating on three-phase alternating-current system limited to 1000 feet distance, the maximum lighting load being 25 per cent of the maximum power load, which is the better system—220 or 440 volts?

This would depend somewhat upon the size of the installation. If it were a large one, 440 volts might be better, on the score of copper economy. If a small one, 220 volts would probably be preferable, for greater simplicity in lamps and lamp fitting.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 149.—Has the 110 and 220-volt, three-wire system, with constant-potential street-arc-lamp current returning on the same neutral wire as the commercial light current, proved satisfactory? If not, what is the trouble experienced?

We have been using constant-potential street arc lamps on 110 and 220-volt system, using the same neutral wire as for the commercial lighting, for nearly three years. The only objectionable feature to this is that there is a momentary dimming of the lights when the street lights are thrown on. We do not consider this of particular importance, however, as it is for such a short time that no one objects to it. For a small plant, we consider this the most satisfactory system that can be used in a three-wire plant. F. L. WILLIAMSON & CO.

If the street lamps are properly balanced on the system, we can not see how they would differ in any respect from the commercial load. If they were not balanced, of course that would produce the ordinary troubles of that condition. We are not quite sure that this question does not refer to the expense of switching in or out a large number of street lamps.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 150.—Should high-voltage wires be strung over or under other wires, and how much clearance should be allowed?

We consider it advisable to string high-tension wires over other wires wherever it is possible to do so. The clearance should be not less than three feet.

High-voltage wires should be strung over other wires, and should have a clearance of at least four feet.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

High-voltage wires should be strung over other wires, and where linemen are to work on the low-tension wires when the high-voltage circuits are alive, a space of 25 inches should be allowed as a clearance between the two sets of wires.

E. H. MATHER.

No. 151.—To prevent danger to linemen and troubles from induction, what should be the minimum vertical distance between the high-tension wires (1000 to 2000-volt) of two different companies occupying the same side of the street or crossing at right angles?

Four feet.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

To prevent danger to linemen, a vertical distance of 25 inches is a reasonably safe clearance between two sets of wires. This distance, however, will not always prevent troubles from induction. E. H. MATHER.

No. 152.—In a monocyclic system with 7300-volt feeders, stepping down to 2200 volts for distribution, should there be a separate system of power mains, or should the power and lighting transformers be connected to the same lines?

Much less trouble from variation of voltage will be experienced if separate power and lighting mains are used. It is impossible to get good lighting service from a transformer supplying a motor at the same time. EDITOR.

Power and lighting transformers should be connected on the same line.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 153.—What size of wire is required to operate seventy-five 60-cycle, constant-current, 7.5-ampere, series alternating arc lamps with 73 volts at arc on a circuit 18 miles long?

No. 6 B and S wire, spaced 18 inches between centres, would make the drop 10.5 per cent.

No. 4 B and S would make the drop 7.2 per cent under the same conditions, assuming that the return wire parallels the outgoing wire throughout the circuit. EDITOR.

No. 154.—Are the present strain insulators for guying safe for from 4000 to 9000 volts?

Yes, if multiplied; one for each 2000 volts or fraction thereof.

GEORGE L. COLGATE.

I do not think they are safe in damp weather, for the dampness causes the current to leak over. H. A. HAMPTON.

Should put several in series.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Our experience with strain insulators at from 4000 to 9000 volts has been that they are not good for any voltage, as they nearly all prove not to be insulators at all after they have been in service a short time. JAS. E. PYLE.

We find that the average "Lieb" insulator stands up under a strain of 3500 to 4000 volts, but would not advise the use of same as a protection against this in a span. Those of porcelain are safe, provided the cracking and breaking can be eliminated.

J. N. ELEY.

No. 155.—Does it add to the danger to linemen working on overhead lines to ground the neutral on 2300-volt primary circui's ?

We do not consider it more dangerous to linemen working on overhead lines when the neutral on 2300-volt primary circuits is grounded. In using three-phase, four-wire system distribution it is better to have the neutral grounded, as it insures a minimum of 2300 volts difference in potential between any phase and ground, whereas, with the neutral not connected to ground the neutral would operate under normal conditions at ground potential, and under other conditions of operation when there was a difference of insulation between any of the three phases and ground, the potential of one or more of the phases might rise to considerably more than 2300 volts, thus making it more hazardous to linemen than if the neutral were positively grounded. HOMER E. NIESZ.

No. 156.—What method of grounding lightning arresters and transformer secondaries gives the best ground at the least cost?

Lightning arresters and transformer secondaries are grounded in Chicago by the use of a piece of one-inch galvanized-iron pipe, 16 feet long, driven eight feet into the ground at the base of the pole, and therefore extending eight feet above the ground. The ground wire is brought down the pole and securely soldered to the top of this tube. This has been found to give a ground of lower resistance than a copper plate, 10 inches by 10 inches, buried six feet under the surface. The galvanized-iron pipe is much cheaper to install, and installations that have been in service for four years are found to be in as good condition as when installed, no considerable corrosion of the pipe having taken place. The soil is chiefly sand and gravel. H. B. GEAR.

No. 157.—What is the ratio of transformer capacity to connected load for (a) *residence lighting, and* (b) *business lighting?*

Where meters are used and block system of secondary distribution, 50 per cent for residence lighting and 75 per cent for business lighting. Where flat rate is used instead of meters, no matter what system of distribution, the ratio should be 100 per cent in each case. L. W. BYERS.

Residence, about three to one. Business on single transformers, two to one. F. VAN der VOORT.

Our transformer capacity for residence lighting is about one-fourth of the lamps installed and for business lighting about three-fourths. F. ELLWOOD SMITH.

Where light is sold on the meter basis, it is found that it is sufficient to install transformer capacity that is from 15 to 20 per cent of the load connected. The ratio is somewhat higher for small residences and apartments than for large residences. The capacity required for business lighting, where there are a number of consumers on one transformer, is about 80 per cent of the connected load. If alternating arc lamps are used extensively, it may be necessary to install 100 per cent or more, in order to provide sufficient current-carrying capacity for the lagging current of the arc lamps. H. B. GEAR.

We have established a ratio of 40 per cent in transformer capacity to connected load in residence lighting and 90 to 100 per cent in business sections.
YOUNGSTOWN CONSOL. GAS AND ELEC. CO.

No. 158.—In what way can a test be made for finding the efficiency of transformers in place? How can such transformers be tested for aging? How should such a record be kept?

A practical way to determine the efficiency of a transformer in place, is to open the primary and apply normal secondary pressure to the secondary through a Weston or similar wattmeter. This will give the core loss. To get the copper loss, short-circuit the secondary through a Thomson or similar ammeter having the proper range. Through a non-inductive adjustable resistance in series with primary, apply current from an auxiliary transformer through a wattmeter attached to the terminals of the transformer under test, adjusting the resistance until the ammeter in the secondary circuit shows full-load current. The wattmeter in the primary will then read the copper loss. The efficiency is the ratio of the full-load output to the sum of such load plus the core and copper losses. If there is no auxiliary transformer connected near the point of test, a small one must be taken to the place. Its capacity need not be over five per cent of that of the transformer to be tested.

The aging of the iron of the core is best noted by measuring the core loss from time to time by the method given above.

HARRIS J. RYAN.

Should not care to test transformers in place. A test of transformers when new, or when a month or so old, would give the aging. Cannot see much use in keeping such a record for individual transformers.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

I would suggest that the transformers be cut loose from both primary and secondary line, and by use of small transformer and wattmeter the test can be made by connecting the primaries of small transformer to line and secondaries of line transformer with wattmeter circuit. The core losses can then be read from the wattmeter. JAS. E. PYLE.

To determine the efficiency of a transformer it is necessary to know the core and copper losses. Where a transformer is already installed the losses can be measured by means of a portable testing outfit. This testing outfit should consist of a step-down transformer, wattmeter, voltmeter, ammeter, and resistance, preferably of lamp banks, and can be mounted on a suitable board and transported from place to place in a wagon.

To determine the efficiency of transformers it is first necessary to determine the core and copper losses, which constitute the losses of the transformer. The core loss or iron loss is the energy used up in maintaining the alternating magnetism in the iron core. This loss consists of two components, the hysteresis loss and the eddy-current loss. For practical purposes it is not necessary to separate these losses, and they are generally measured and kept track of as total core loss only.

To determine the core loss it is necessary to disconnect the primary fuses, and cut out all load on the secondary lines. Figure 1 shows the necessary connections for this test. It will be noted that the high-potential side of the transformer is open-circuited, and the two cables or conductors from the instruments and source of supply are connected to the secondary leads of the transformer. It is assumed that the frequency of the current is correct, and the voltage obtained from the secondary of the step-down transformer should be equal to the voltage of the secondary circuit of the transformer to be tested. In case this voltage is too high it can be cut down by inserting in series a resistance, either lamps or rheostat. When the conditions are correct, and the instruments are connected as shown in Figure 1, readings should be taken on the voltmeter, wattmeter and ammeter. The ammeter reading should be taken only when the potential coils of the wattmeter and the voltmeter are open, in order that the current passing through these two coils shall not be added to the exciting current indicated by the ammeter.

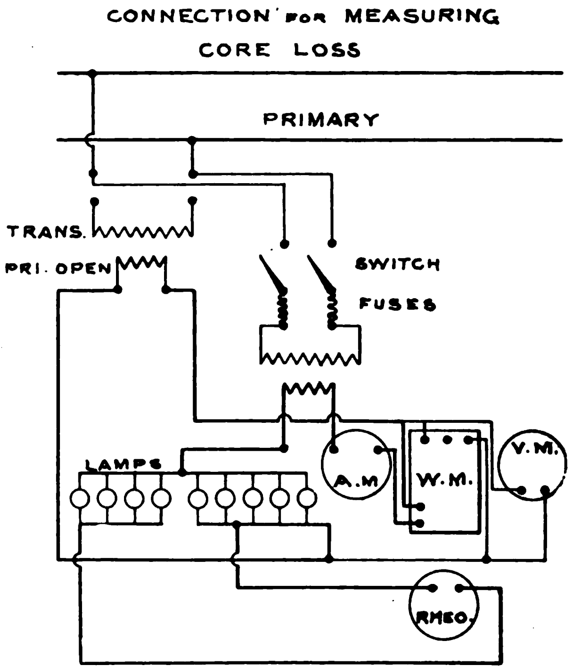


FIG. 1

In taking the reading of core loss in watts on the wattmeter, if the voltmeter is connected in circuit as shown the wattmeter will indicate the loss in the voltmeter and in the shunt coil of the wattmeter in addition to the core loss of the transformer, and these should be subtracted from the reading. If the reading of wattmeter is taken with the voltmeter open-circuited it will not be necessary to make any correction for loss in the voltmeter, but the correction of loss in the wattmeter can be calculated by the formula : $\frac{\text{Volts}^2}{\text{Resistance of shunt coil.}}$ After making these corrections, the result is the core loss of the transformer (see Figure 1).

In measuring the copper loss (Figure 2) the secondary leads or cables should be effectively short-circuited as close to the transformer as possible, and the conductors from the testing outfit should be connected to the primary cables ; care being taken that all joints are carefully made in order to avoid errors due to the resistance of joints. Current should then be allowed to flow through the primary coil, this current being adjusted by means of the rheostat and lamp-bank resistance until it is just equal to the full-load primary current ; the reading then indicated by the wattmeter, after subtracting the losses in the voltmeter and in the shunt coil of the wattmeter, as in the previous case, will indicate the copper loss of the transformer. This copper loss is as a rule somewhat higher than the calculated C^2R, due to the eddy currents in the windings of the transformer. The potential indicated by the voltmeter shows the impedance voltage, and varies from three per cent to six per cent of the primary voltage of the transformer, depending on the design and frequency of same. For example, if we take a modern five-kw, 2000-volt transformer, it will be found that from 65 to 75 volts will be required to force two and a half amperes through the primary at 60 cycles with the secondary short-circuited, and by obtaining the core and copper losses, the full-load efficiency of the transformer is ascertained as follows :

Per cent efficiency =

$$\frac{\text{Watts output}}{\text{Watts output} + \text{Core loss} + \text{Copper loss}}$$

or

Per cent efficiency =

$$100 - \frac{\text{Core loss} + \text{Copper loss}}{\text{Watts output} + \text{Core loss} + \text{Copper loss.}}$$

The second formula is a much more accurate way of calculating the efficiency, especially if a slide rule is used to make the calculations.

To calculate partial-load efficiencies, ascertain the copper loss for that load and proceed as above. This loss varies as the square of the load; that is, at half load the copper loss is only one-quarter of what it would be at full load, and at one-quarter load the copper loss is only one-sixteenth of what it would be at full load. The core loss is constant for all loads.

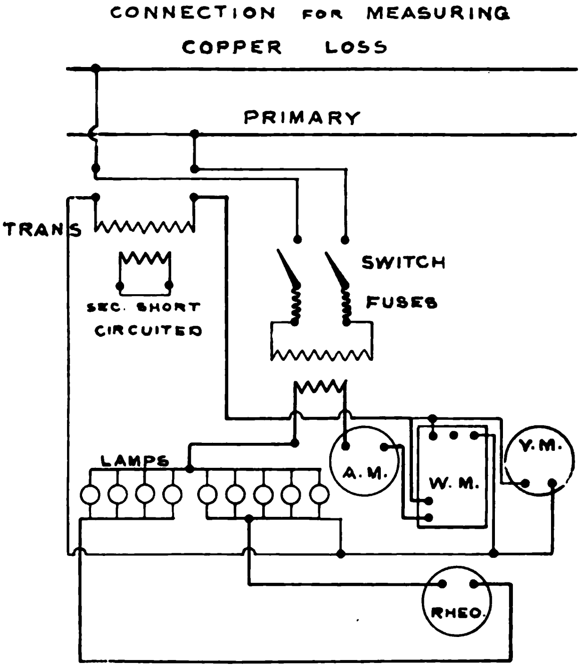


Fig. 2

To ascertain the amount of aging in a transformer it is necessary to measure the core loss under the same conditions; that is, the frequency, voltage and temperature, at different periods of time, say every three months, or at longer periods.

It is important that the correction factor of the instruments be ascertained whenever the core losses are taken, in order that accurate results may be obtained.

Perhaps the most convenient method of keeping track of the core loss is to tabulate the results on a card, one card being used for each transformer, spaces being provided for the readings of the frequency, voltage, core loss, temperature and the instruments used, with their correction factors.

EDWARD A. WAGNER.

The mere test for aging is a very simple matter. It consists simply in reading at fairly long intervals of time the energy consumed by the unloaded transformer, by means of an indicating wattmeter of any of the ordinary types. The lamps must be disconnected from the transformer, the shunt coil of the wattmeter connected to the supply mains, and the series coil inserted in one of the leads to the transformer. The only difficulty is in making the connections. Of course if the transformer is in a suitable place and has suitable current available, the test may be made on the low-tension side equally as well as on the high. JOHN F. KELLY.

In cases where two or more transformers are permanently connected to the same secondary circuit, or may be temporarily connected, the core loss of any one transformer may be readily obtained by opening the primary circuit, by removing the primary fuse of the transformer and inserting a wattmeter between the secondary of the transformer and the secondary distribution circuit. FREDERICK BEDELL.

No. 159.—What is the best method of locating fuse blocks on a primary distributing system?

Fuse boxes or switch cut-outs about every 1000 feet to section line. Branch cut-outs on every branch, to facilitate finding grounds and short-circuits. F. VAN der VOORT.

No. 160.—What form of primary fuse is found to give the best results?

Cartridge fuses. EDITOR.

We have secured the best possible results from a convenient, well-made, open fuse block, supplying the same with asbestos-covered fuse. An asbestos-covered fuse may be quickly secured by slipping asbestos tubing over the fuse.

YOUNGSTOWN CONSOL. GAS AND ELEC. CO

had not shown at the station for some minutes past. The usual tests located the ground at a service hole some feet down the street. Had this cable been solidly connected at intersections, there is no doubt that considerable trouble would have resulted. J. N. ELEY.

No. 166.—Have you had any trouble with oil switches failing to open circuits in case of trouble due to short-circuits or other causes?

(Note.—Questions 166, 167, 168 and 169 refer to circuits operating at 6000 volts or more from stations having several thousand kilowatt capacity in generators.)

Oil switches have invariably opened short-circuits satisfactorily. H. G. STOTT.

No.
THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 167.—Have you had any burnouts on high-tension transmission cables, and if so, how were they caused and how much damage was done?

Yes; caused by bad joints. Very little damage done. Never more than two feet of cable destroyed.
H. G. STOTT.

We have had a number of burnouts. It is practically impossible to say how they were caused. We have had one or two manholes completely burned out, but this is the exception; it is usually limited to two or more adjacent cables.
THE EDISON ELEC. ILL'G CO. OF BOSTON.

No 168.—What method do you use for protecting high-tension cables from manhole fires?

Wrap cables with two layers of one-fourth-inch asbestos sheet. Lead sheaths of cables are practically insulated all over. H. G. STOTT.

We build manholes with individual shelves for separate cables.
THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 169.—Have you had any trouble caused by stray currents flowing on the lead sheath of transmission cables, and do you use any method for breaking the continuity of the lead sheaths on these cables?

We do break the lead sheath.
THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 170.—What should be the per cent drop in voltage on a well-equipped alternating-current line between station and centre of distribution?

Two per cent. H. G. STOTT.

The drop in voltage on alternating-current lines between the station and the centre of distribution should not exceed the voltage range of the generator, which is usually 10 per cent. Where spare generating capacity is of value, the per cent loss should be such that the sum of fixed charges on the investment and the value of line losses will be a minimum. In the majority of plants this will result in feeder losses, varying from four to 10 per cent, according to the length of the feeders.
H. B. GEAR.

Not over five per cent.
THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 171.—What is the best way of testing meters on the consumer's premises?

Cut consumer's lighting around meter, using a bank of lamps for testing load. For direct-current use ammeter, voltmeter and stop-watch. For alternating current use voltmeter, indicating wattmeter and stop-watch. L. W. BYERS.

The ordinary process of testing a recording watt-hour meter with an ammeter, voltmeter, stop-watch and slide-rule, has become so familiar to persons thus occupied that a great many do not properly realize how roundabout the method really is.

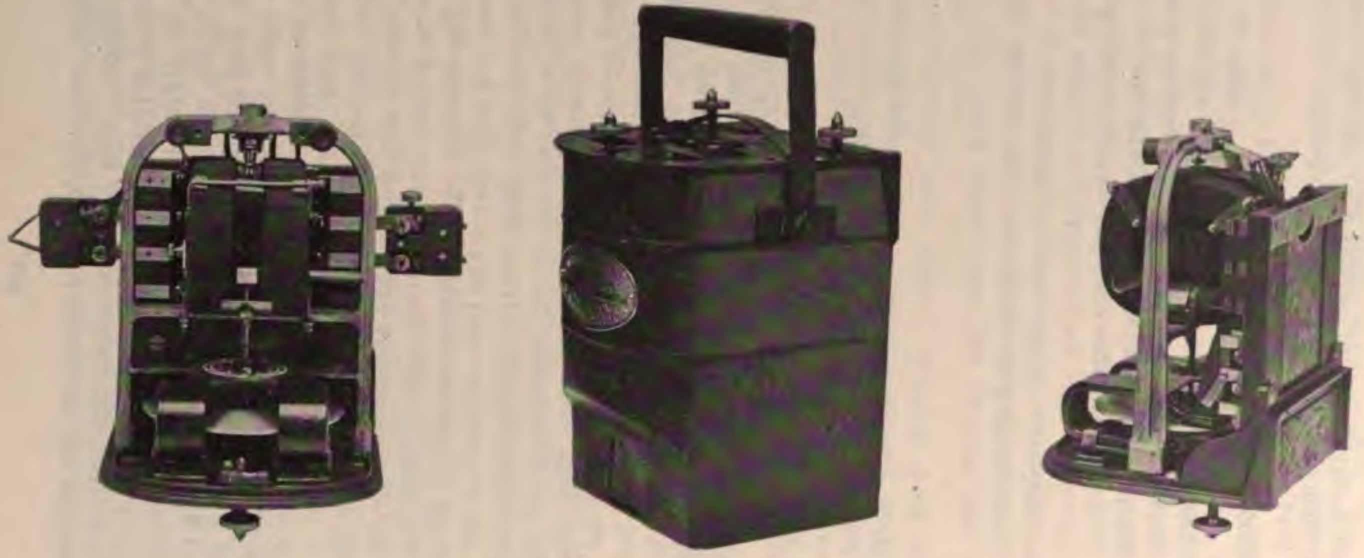
In order to bring out the above, let it be supposed, for example, that it were required to check, commercially, 10,000 ordinary indicating voltmeters. It is easily appreciated that the only *practical* method would be to use a standard indicating voltmeter. Instead of doing this, however, the above 10,000 voltmeters *could* be checked by using four separate instruments, namely, a recording watt-hour meter, an ammeter, a stop-watch, and a slide-rule. The operation of finding the per-cent error of each of the 10,000 voltmeters would then be as follows: The recording watt-hour meter would first be timed with the stop-watch for a certain number of revolutions and the number of watts being used would be calculated by the slide-rule. These watts divided by the amperes would give the correct volts, and this, in turn, divided into the reading of the voltmeter that is being checked, would give the per cent accuracy of the voltmeter. Such a method of checking a voltmeter would of course be absurdly roundabout and laborious, but not a particle more so than the ammeter-voltmeter-stop-watch-slide-rule method of testing recording wattmeters.

The gist of the foregoing is that where a large number of instruments are to be checked, the standard with which they are to be compared should be one instrument, and should read in units similar to those of the instrument being tested. The best way to test a large number of recording watt-hour meters, therefore, would be to use a standard watt-hour meter.

However, accurate results can not be obtained by simply taking an ordinary watt-hour meter, and using it as a standard, for the reason that all watt-hour meters—and especially those of the commutator type—are notoriously inaccurate and unreliable on light loads. If, however, instead of one meter, several watt-hour meters, ranging in capacity from one to 150 amperes, were used, it is evident that the load to be measured could always be connected to a test meter of approximately the same capacity; in other words, none of the test meters need be run at the inaccurate portion of their scale, namely, light load. This, supposing that two voltages were used on the system, would perhaps necessitate the use of eight test meters.

Although the above scheme would insure accuracy, because each test meter would only be used at approximately full load, and although a saving of numerical labor would be effected by using standards reading directly in watt-hours, it would obviously be impracticable, owing to the large variety of test meters necessary to be carried.

The writer, engineer of the meter department of the Brooklyn Edison Company, has developed a system of testing meters on the consumer's premises, using a single portable watt-hour meter. This instrument, although no larger or heavier than an ordinary watt-hour meter, accomplishes the



Mowbray Portable Watt-Hour Meter

same results that would be obtained by the aforesaid eight separate meters. This condensation of eight meters into one is accomplished principally by winding the field coils in several sections of different carrying capacities. By changing the position of the connecting plug, and thus shifting the current from one field winding to another, the capacity of the instrument is made one, two, ten amperes, etc., depending on the load to be measured. By changing the position of another connecting plug, the armature circuit is adapted to 115, 230 volts, etc. The per cent fast or slow of the meter being tested is read instantly and without any numerical labor, by means of a revolving pointer and a circular scale divided into 100 equal parts. The accuracy and quickness secured by the use of this instrument are such that it has been adopted by the Brooklyn, New York, and other large electric-lighting companies.

Owing to the fact that most companies prefer to build the instrument themselves, using meter parts that they carry in stock and possibly making slight changes to meet local conditions, the instrument is not on the market, but sufficient specifications, drawings, etc., to enable it to be built in any company's machine or meter shop can be obtained from the writer. A more detailed description of the scheme appeared in the *Electrical World and Engineer* of March 21, 1903.

W. J. MOWBRAY.

No. 172.—What degree of accuracy at five per cent of full load is it practically possible to maintain on wattmeters of the commutator type?

In 1900, some meters that had received only nominal inspection showed the following average efficiencies.

299 meters, 78.9 per cent on 5-per-cent load
158 " 75.9 " 5 " "

Some of the following had been regularly tested :

585 meters, 80 per cent on 5-per-cent load

Some of the results of this year's regular inspections showed :

514 meters, 91.8 per cent on 10-per-cent load
1254 " 90.8 " 10 " "

GEO. ROSS GREEN.

From a record of the annual tests that I made while serving as meter engineer on a system in which there were over 2000 commutator meters in service, I found that the average percentage of error on full load was two and one-half per cent; this error being almost always fast. This does not include meters that were damaged or otherwise out of order, such, for example, as having an open armature coil. Of the entire number of meters in service about three per cent were annually found to be in this latter condition, and running about 20 per cent slow.

JOSEPH SHOWALTER.

At five-per-cent load we find an *average* error of about 10 per cent on small-capacity meters, and about five to seven per cent on large-capacity meters.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

We can maintain 80 to 85 per cent on meters up to 50 lights, and on from 50-light to 100-light meters we get 85 to 90-per-cent accuracy at five per cent of full load.

FRED. B. HUBBELL.

We should say that the degree of accuracy of wattmeter at full load should be very good if meters are properly looked after and cleaned and rejeweled as often as circumstances seem to require it. We think each station manager should make his own rules governing the cleaning of wattmeters. It has been our experience that meters in some installations require cleaning and inspecting oftener than others. We know no rule that will suit in all cases, but firmly believe that the degree of accuracy on all light loads depends largely upon the care given the meter.

JAS. E. PYLE.

I believe that the accuracy at five per cent of full load, which it is desired to maintain in a wattmeter of brush-type, depends on whether or not the meter is fitted with an adjustable shunt and upon the frequency of meter testing. It has been my personal experience with a large number of brush-type meters that were not fitted with an adjustable shunt, that at five per cent of full load the average error at the time of making the annual test was about 25 per cent slow. I have no doubt that this error could be very much decreased if the adjustable shunt were used.

These meters were invariably adjusted to run correct within three per cent. I have never made any extensive tests on meters as to how rapidly the average error of 25 per cent slow was reached, but I am of the opinion that a change is much more rapid during the first three months than afterwards.

P. A. BERTRAND.

Within 20 per cent. Meters should be inspected every three months. GEORGE L. COLGATE.

No. 173.—What is the maintenance cost per kw-hour of the different types of Nernst lamps?

With reference to the maintenance of the lamps, would say that they give us very little trouble; perhaps less trouble than we experienced with our arc lights that are used for illuminating various parts of our works. A. C. EASTWOOD.

We have no means of determining this point accurately. Whatever faults there are in the lamps in our service are due to the current furnished by the local station. The voltage is higher in the morning than after five o'clock, and in using the lamps continuously the glowers burn out much quicker than they do in evening work only, proving conclusively that the voltage is too high. We have considered changing glowers, but feel that it would reduce the efficiency, and we prefer the extra cost. COES WRENCH CO.

Almost all of our Nernst lamps are installed together with incandescent lighting on the same meter, only three customers having unmixed Nernst lighting. It is from these that we make our calculations of cost, which is very close to one-half cent per kw-hour for glower renewals and about a quarter of a cent per kw-hour for maintainance. We are satisfied that these figures are liberal. E. F. PHILLIPS.

No. 174.—What is the ratio of burnouts in a Nernst lamp between the ballasts and glowers of the lamp?

The ratio of burnouts between ballast and glowers is one ballast to one hundred and six glowers.

JOHN C. SCHIESS.

In a test lasting several weeks we found that we replaced five ballasts to one hundred and thirty-three glowers, or about one to twenty-seven. CHAS. A. DAVIES.

With the six-glower lamps the ratio has been seventeen heaters to three ballasts, and with three-glower lamps two heaters to three ballasts. We do not consider that we have had the lamps in operation long enough to make this ratio of any value. INTERNATIONAL HARVESTER CO.

We have had so few burnouts of ballasts in actual operation that the ratio is necessarily very small. In some of the first lamps we received, provision was not made in the lead wires to allow us to fasten the glowers in properly and in some cases the glowers got together, thereby throwing an extra strain upon the ballasts and burning them out. Since this difficulty was remedied we have had but very few burnouts; in fact, we have not lost a ballast in five or six months.

E. F. PHILLIPS.

We have burnt out only one ballast since the lamps were installed. Should say that the ratio was about one per cent.

COES WRENCH CO.

Insignificant. C. W. RICE.

No. 175.—What results, as compared with arc lights, has the Nernst lamp given for street lighting?

We believe the Nernst lamp for street lighting in country towns is much more satisfactory than the inclosed-arc lamp, for it gives frequent units where they are wanted—underneath trees, etc.—while on account of these trees an arc lamp would not have a chance to cover the ground that it should cover.

THE UNION ELEC. LT. AND PR. CO.

We consider that we get about the same illumination from a six-glower lamp as we do from an inclosed-arc lamp with about the same wattage, and, of course, a far better power factor. INTERNATIONAL HARVESTER CO.

Favorable. C. W. RICE.

No. 176.—Do Nernst lamps prove troublesome in their operation?

On the whole, Nernst lamps do not prove troublesome in their operation. THE UNION ELEC. LT. AND PR. CO.

We have found Nernst lamps much more troublesome than incandescent lights or inclosed-arc lamps.

W. C. ANDERSON.

We have some 275 Nernst lamps, ranging from one to six glowers each, and they never fail to light except in rare cases and then only on account of loose connections, burnouts, or a glower being too far away from the heaters.

CHAS. A. DAVIES.

From some rough experiments that we have conducted, we consider that to give the same illumination with incandescent lamps would require an increased current consumption of 93 per cent. For instance, in one section of our machine department which is lighted by eight three-glower Nernst and fourteen 16-cp incandescent lamps, we should have to use, to get the same illumination with the same distribution, ninety-four 16-cp incandescent lights. The relative wattage is :

8 3-glower Nernst lamps at 278 watts ..	2224 watts
14 16-cp incandescent lamps at 64 watts.	896 "
Total..............	3120
94 16-cp incandescent lamps at 64 watts.	6016 watts
Difference..........	2896

or 93 per cent. If we had lighted this section of the shop with incandescent lights, however, we should not have installed ninety-four lights, but only fifty-three, distributed in the following manner : Eight three-light clusters for general illumination and twenty-nine lights placed as needed at the various machines. This would make our relative watt consumption

8 3-glower Nernst lamps at 278 watts..	2224 watts
14 16-cp incandescent lamps at 64 watts.	896 "
Total..............	3120
53 incandescent lamps at 64 watts......	3392 watts
Difference..........	272

or 8.7 per cent.

This lighting by fifty-three incandescent lamps would give us an illumination on a par with that of our shops that are lighted entirely by incandescent lamps, but would not give us what we should call a *well-lighted* shop.

To determine the number of incandescent lamps necessary to give the same illumination as a Nernst lamp, we hung a cluster as close as possible to and on a level with a Nernst lamp. Between the two sources of light, and extending from floor to ceiling, we hung a piece of roof paper three feet wide and varied the number of lamps in the cluster until we got the same degree of illumination (as judged by the eye) at a distance of 15 feet on each side of the screen. We chose to get this distance from the lamps, as the distribution of light is very different and it seemed that at this distance the conditions were nearer uniform.

We find the Nernst lamp to be very good for general lighting and for general work, but rather difficult to use to its full advantage for fine distribution about machine tools, for which work the incandescent lamp is best fitted, as it can be brought close up to the edge or point of the tool. Nevertheless, for the same consumption of power we do get a much better lighted shop in quantity and quality by using a combination system of Nernst and incandescent lighting.

INTERNATIONAL HARVESTER CO.

No trouble whatever. COES WRENCH CO.

We have had little or no trouble in operation.

E. F. PHILLIPS.

No. C. W. RICE.

No. 177.—As Nernst lamps consume much less current than other lamps in proportion to illumination, how is the customer charged for this service?

Our use of the Nernst lamp is confined almost exclusively to street lighting, and in this case we charge a certain sum per lamp per year, endeavoring to strike a fair price, taking into consideration the candle-power furnished and the wattage consumption of the lamp. In the one store in which we have these lamps in use for commercial lighting, we meter the current the same as on any incandescent circuit.

THE UNION ELEC. LT. AND PR. CO.

Where the company furnishes the Nernst lamps they are on contract, and on meter where the consumer purchases them.

W. C. ANDERSON.

Customer is charged at the same rate as for incandescent lighting, on the same principle that a gas customer is charged no more per 1000 feet for his gas when he uses a Welsbach burner.

C. W. RICE.

We sell all our current by meter, with a base rate of 16 cents per unit. For Nernst lamps we require customers to pay a minimum of $1.60 per month, which is at the rate of 16 cents per unit for the first ten units per month for each three-glower lamp installed, which covers one and one-third hours' lighting per day; all other units sold at five cents per unit. Compared with the above, other classes of lighting carry a minimum charge equal to one hour per day.

E. F. PHILLIPS.

No. 178.—Are Nernst lamps furnished by the lighting company, or do the customers, in the majority of cases, furnish their own lamps?

The company furnishes the Nernst lamps for street lighting, but expects consumers to furnish their own lamps for commercial lighting, the company furnishing the renewals free. Of course, if the company had contracts for lighting large stores, or similar places, at a flat rate per year, it would probably be to the company's interest to furnish Nernst lamps, on account of the saving in wattage consumption.

THE UNION ELEC. LT. AND PR. CO.

We have not found any one willing to pay for Nernst lamps for private-house use, and there is no other field in the territory covered by our alternating-current lines, so their use with us has been restricted to one store; in this case the company has furnished lamps.

W. C. ANDERSON.

Both.

C. W. RICE.

We buy our own lamps. We understand that the lighting company has supplied lamps for some firms, but do not know that it has supplied Nernst lamps.

COES WRENCH CO.

In consideration of the minimum charge noted under Question No. 177, the company furnishes and maintains the Nernst lamps, but nothing smaller than a three-glower lamp.
E. F. PHILLIPS.

No. 179.—Has any one put Nernst lamps to a commercial use?

At present we have these lamps used commercially in but one place, where we understand they are very much liked.
THE UNION ELEC. LT. AND PR. CO.

We have several Nernst lamps burning on meters, in stores. We have had these lamps in for about six months, and they give us very little trouble. We have had four glowers to break and one ballast burn out in that time. We think, however, that the burning-out of the glower was more our fault than the fault of the glower, from the fact that the glowers were placed too close to the heater.
A. M. JONES.

There are hundreds of installations of Nernst lamps in commercial use.
C. W. RICE.

We have 110 three-glower lamps in service for commercial use.
E. F. PHILLIPS.

We have used the lamp in offices, over pattern benches, and in all places where light is an absolute essential. Men working on patterns made of brass for foundry work claim that they can do better work with one Nernst lamp than with three 16-cp incandescents, because the light is white, steady, and at the same time not glaring, enabling them to work to a line and small dimensions if necessary. We use the ground-glass globes.
COES WRENCH CO.

We now have in service Nernst lamps aggregating 200 glowers in single, three-glower and six-glower lamps, and are greatly pleased with the quantity of illumination secured. They are at present used throughout the drafting-room and office and they illuminate the pattern shop.
A. C. EASTWOOD.

No. 180.—Are Nernst lamps as efficient on watts consumed as claimed by manufacturers?

Our experience has been that the Nernst lamps are fully as efficient on watts consumed as claimed by the manufacturer, we having had a wattmeter on a circuit which registered an average consumption of 85 watts per glower.

THE UNION ELEC. LT. AND PR. CO.

We believe they are.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

On recent tests of short duration we obtained the following results :

Test No. 1

Total number of glowers burning (being a number of 1, 2, 3 and 6-glower lamps)	269
Kilowatts consumed	20.5
2500 divided by 269 equals	76.2 watts per glower
76.2 divided by 225 volts equals	.33 amperes per glower

The manufacturers give the consumption of energy as 88 watts at .4 ampere.

Test No. 2

Number of glowers burning	153
Kilowatts consumed	12.75
12.750 divided by 153 equals	83.3 watts per glower
83.3 divided by 230 volts equals	.362 amperes per glower

Test No. 3

Number of glowers burning	80
Kilowatts consumed	7
7000 divided by 80 equals	87.5 watts per glower
87.5 divided by 230 equals	.38 amperes per glower

In test No. 3 about one-half the lamps in use were of the one-glower type, while in tests Nos. 1 and 2 the majority were of the two, three and six-glower type.

CHAS. A. DAVIES.

We have made a test of the watt consumption, finding that it averages about 85 watts per glower on our street circuits.

CHARLES G. BILL.

From tests I have made on three-glower lamps fitted with 232-volt glowers, I find the watt consumption to be 278 instead of 264, as given in the Nernst Lamp Company's catalogue No. 2. These lamps have been in service about three months. I have not been able to make tests on the other sizes of lamp.

INTERNATIONAL HARVESTER CO.

All our tests show an efficiency of .4 ampere per glower, or 86.4 to 88 watts per glower, which we believe is the efficiency claimed by the manufacturers. E. F. PHILLIPS.

Yes. C. W. RICE.

No. 181.—What is the average life of Nernst-lamp glowers on good regulation, from practical experience?

Our average life of glowers has been a trifle over 800 hours, running from 800 to 810 at different times.
THE UNION ELEC. LT. AND PR. CO.

Our experience, covering 35 Nernst lamps, is that their life on 125 cycles and 210 volts with good regulation, for alternating-current work, will average about 400 hours.
W. C. ANDERSON.

The average life of the glowers is holding well up to the 809 hours that we secured on the first year's work.
CHAS. G. BILL.

Our observations show an average life of about 650 hours.
E. F. PHILLIPS.

The average life of glowers with us is about 200 hours. The shortness of life is due to the variation in voltage of current furnished by the local station, the variation in actual test being from 100 to 108 volts. We have seen it drop to 96 for several seconds, and have had our lamps flare to 112 volts. This was temporary only, but sufficient to burn out delicate parts, and is extremely unsatisfactory in ordinary service. We have endeavored in ordering glowers to strike an average, but we are using glowers for 104 volts and .8 ampere. The voltage at meter runs from 107 to 103 volts. We prefer to renew glowers rather than cut down the efficiency of the light.
COES WRENCH CO.

Eight hundred hours on 60 cycles and 220 volts.
C. W. RICE.

No. 182.—What globes have you found for interior arc lighting that are more decorative than the plain white or clear glass, and *within reason as to cost and weight, while not absorbing more light than an opalescent globe?*

We haven't found any.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 183.—What are the probable future relations between heat supply and light and power in both residence and business districts?

No. 184.—What percentage of loss between the station metered output and the customer's metered current should be considered good results in a station having an annual output of 800,000 kw-hours?

The percentage of loss between station and customer depends on the system used and the character of the installation.

In an alternating-current system having a large number of small transformers, small feeder lines and poor meters, it is frequently as high as 60 per cent. Few of the smaller plants I have examined show better results than 40 to 50 per cent if they operate 24 hours per day, and I should consider anything between 30 and 40 per cent very fair. With Edison stations, the loss varies from about 15 to 35 per cent. In a station showing as low a loss as 25 per cent in its constant-potential system there must be a first-class meter department and low copper losses.

I think a much larger per cent of this loss than is generally supposed is due to the constant loss in the meter potential circuit and to the inefficiency of the meter on light loads. This may easily amount to 15 per cent or more of the entire station output.

EDITOR.

The loss between station and consumers' meters depends largely upon the load factor of the station. This is even more pronounced in an alternating-current station than in a direct-current station. The questioner has not given sufficient information to enable any one to answer intelligently. Transformer core loss is a constant, and goes on 24 hours a day. You will notice that in this station the output is 800,000 kilowatts per annum. If this entire load were uniformly distributed throughout the 8760 hours in a year, it might be taken care of by a 90-kw generator and 90-kw capacity in transformers. If the station is an alternating-current station, the sales probably do not amount to more than 450,000 kilowatts per annum, and it probably requires for the generation of this current 500-kw capacity in machines, and lines are probably equipped with not less than 900-kw capacity in transformers. Assuming that the sales are 450,000 kilowatts per year, if this were a steady load throughout the 8760 hours in a year, the loss would be so greatly reduced that a 50-kw generator and an equivalent capacity in transformers would be sufficient for the company's needs. The point I am trying to make clear is that the loss between the station meters and the consumers' meters is more largely due to capacity demanded by all consumers simultaneously than by the output of the station. The resistance drop on the lines is largely due to unequal distribution of load in regard to time, while transformer core loss and meter shunt loss are a factor of time and capacity only, and bear no relation whatever to the sales of current. C. W. HUMPHREY.

No. 201.—Would it not be advisable to establish a standard system of reports for the operation of electric plants? In order to accomplish this, each member should submit a sample of his reports, and the whole should be submitted to a committee to suggest a standard form.

I do not believe that a standard system of reports could be devised that could be used with good results in all plants. Local conditions must influence the style of the report. Sample reports from a number of stations would be of assistance in drawing up new forms, but each station should have its own forms. F. ELLWOOD SMITH.

Yes. W. S. BARSTOW.

A collection of operating reports would be valuable, and by this is meant operating and technical reports rather than financial. Whether this would lead to the adoption of a standard form it is difficult to say in advance, as local conditions must, to a great extent, determine the forms.

H. M. E., N. Y. ED. CO.

No. 202.—Which has been found most satisfactory in small towns—meter or flat rates, or a combination of the two?

We have found meter rates much more satisfactory than flat rates, except for commercial lighting, where the circuit is cut out at a certain time each night. E. E. LARRABEE.

To me it seems that flat rates are not desirable either in a small town or a large town, unless, perhaps, where the plant is operated by water-power. F. ELLWOOD SMITH.

Meter rates are most satisfactory. A. O. FRETZ.

We have wired up in this place nearly 3000 incandescent lamps, 16-cp basis. We found it necessary either to install meters or increase our capacity, and our revenue did not seem to warrant the latter. By putting about 50 per cent of our customers on meters, selecting those of large installation, particularly in residences, we now find that we have plenty of capacity, with our revenue slightly increased. We consider it advisable to put all customers on meters. S. S. INGMAN.

Whatever else is done, avoid flat rates. Some system along the lines of the Doherty and Foresee systems seems to the writer the most rational and equitable system of charging.
ALEX. J. CAMPBELL.

We find a combination rate best; flat rate for a certain number of lights always in use, and meters where customers want to use more or less. C. P. WELLES.

For a small town, or, in fact, for any town in which the motive power of the electric plant is steam, it would seem as if meter rates were an absolute necessity; applied in either the Doherty or some other form based upon the maximum demand of each consumer, they should leave very little to be desired. For a water-driven plant the question is more open, but in a general way experience would indicate that it is better, when possible, to supply all by meter or all by flat rate. The flat rates, however, should be controlled by some maximum-demand instrument. An open, uncontrolled flat-rate is undesirable under any circumstances, being open to so much abuse, the temptation to take advantage of it being too strong for many people. THE SHERBROOKE PR., LT. AND HT. CO.

The meter plan is the best. Flat-rate consumers nearly always use more light than is necessary. If an attempt is made to combine the two, there will be complaint of discrimination.
C. C. GILES.

Every installation of less than five lights, on a flat rate ; all over that, on a meter. FRED. B. SHARPE.

I should say meter rate. It prevents waste, both in lamps and in current. E. S. BOSWORTH.

Unquestionably, meter rates are more satisfactory in the long run, both to the supplying companies and to the consumers. Under flat rates the consumers get a great deal more than they pay for or want, and the supplying companies give a great deal more than they are paid for. Where metering is possible—and it should be possible everywhere excepting for street lamps – it should be employed.

A. W., N. Y. ED. CO.

This is a matter that is governed by local conditions. As we are situated, not operating a day service, we find that a combined flat and meter rate is the most practical, although on 24 hours' service we would not consider flat rates, unless for one or two lamps only. W. J. TROTT.

By no means use a flat rate except, possibly, in arc-light work, and only on circuits controlled separately at the station. These lights are to be further protected by installing an interrupting device to prevent overreaching on the part of the consumer. GUY C. GUM.

In very small towns where there are no very large consumers, I think that flat rates should be used, and that every house should be fused up for its maximum demand, with fuse-boxes sealed. This is only applicable to places where the expense of buying and maintaining a meter would materially cut down the profits per consumer. In large, or medium-sized towns, where the average consumer uses considerable current and the meter expense would not be so large an item, I think it is always advisable to put consumers on a combination basis, such as the Doherty rate, where a certain fixed "readiness-to-serve" is charged on every lamp demanded, a certain consumer charge on each consumer, and a small meter rate in addition. It is needless to dwell upon the merits of this system, as it has been thoroughly discussed at previous meetings.

C. W. HUMPHREY.

We are operating an electric-light plant in a city of 3500 population. We started out giving 12-hour service and flat rates five years ago, but we are now giving 24-hour service and making no new contracts above two lights except they be on meter. We have a number of flat-rate contracts still in force and find them very unsatisfactory, although we are operating by water-power. Were we not using a large amount of power for other purposes, we should be more favorably disposed toward flat rates, as for some unaccountable reason most people would like to know in advance what the cost is going to be, and we find that many of our patrons would be willing to pay more on a flat rate than light costs them on a meter. Had we no other use for the water than to produce light, the cost would be but little more to generate the additional current and supply them than it now costs us, but as we have other uses for our power, we are decidedly opposed to flat rates and will not make any more of them. F. L. WILLIAMSON & CO.

As a general rule, meters; except in cases where hours of burning are definitely fixed and installation of meters is too expensive. W. S. BARSTOW.

It rarely pays in any case to meter consumers using five 16-cp lamps or less, if you can get 75 cents or more per 16-cp lamp per month on flat rates. By the latter system you save interest and depreciation on the cost of your meter and its connections, all meter repairs, meter reading and testing, lamp renewals and the constant loss in the potential circuit of meter, besides insuring a fixed revenue from consumers winter and summer, and minimizing complaints. It is true that a flat-rate customer invariably uses his lights longer than his contract would allow, but I think the trouble from this source is generally overestimated, unless it arises from the application of flat rates to residences or other installations where the number of lights wired is large in proportion to the number ordinarily used. For example, a 16-cp lamp burning 24 hours per day and 26 days per month would require about 35 kw-hours, which at 70 cents per month would be two cents per kw-hour. How many of us who are anxiously looking for some means of broadening out our load peaks would think of "turning down" a 24-hour customer at two cents per kw-hour? But, as a matter of fact, the most hardened "flat-rater" would hardly average more than 12 hours per day, even on an all-night contract, which would make his rate four cents per kw-hour. Isn't this a gilt-edged return for a 12-hour load?

Compare a five-light installation operating 12 hours a day at 75 cents per lamp per month, with a 25-light installation averaging one hour per lamp per working day and metered at 10 cents per kw-hour net:

	5 Lamps Flat Rate		25 Lamps Meter Rate
Revenue	$45 00		$43 68
Cost of current at one cent per kw-hour (station cost only)	10 51	$4 38	
Interest and depreciation on cost of meter and connections at 15 per cent		2 25	
Loss in potential circuit of meter, at five watts per hour, 365 days per year, at one cent per kw-hour		0 44	
Meter repairs, reading and testing		1 00	
13 lamp renewals at 600 hours' life per lamp, at 16 cents per lamp		2 08	10 15
Net earnings	$34 49		$33 53

In the above comparison no account is taken of the fact that the 25-light metered installation requires several times the station and line investment needed in the case of the five-light flat-rate customer; in some instances, five times as great. If the interest and depreciation on this additional investment are taken into consideration, or the cost of additional current is reckoned at the cost of coal only, the comparison becomes very one-sided. EDITOR.

No. 203.—Which is preferable? To make a high rate per kw-hour and give liberal discounts, say up to 50 per cent, to large consumers, or to make a low rate with a maximum discount of, say, 10 per cent?

The two-rate system of charging by meter, giving a uniform discount of 10 per cent, strikes us as the most favorable to both the company and the consumer, as it gives the long-hour consumer the benefit of the low rate and the discount, and makes the short-hour consumer come nearer standing his portion of the ready-to-serve cost. E. E. LARRABEE.

We prefer as low a kilowatt rate as possible, for the reason that our customers, comparing notes with other cities, see that part of it first and are apt to ignore the discounts entirely in making comparisons. S. S. INGMAN.

If straight meter rates are used without a minimum or fixed service charge, the writer would strongly advocate a higher rate per kw-hour with liberal discounts, rather than a lower rate per kw-hour with a maximum discount of, say, 10 per cent. ALEX. J. CAMPBELL.

High rate with discounts. C. P. WELLES.

Speaking locally, after a strong campaign in favor of municipal ownership, a low rate with a maximum discount of 10 per cent is preferable. Ninety per cent of the arguments against excessive cost of lighting are based upon the gross amount of the bill before the cash discount is taken off. Our meter bills bear a discount of thirty-three and a third per cent, while our maximum-demand bills have discounts of from five to ten per cent for cash, and we find that the latter are fully as effective in securing prompt payment as the larger discount, while the results of a discount loss are not nearly so serious, the consumer being sore in proportion to the size of the discount lost.

THE SHERBROOKE PR., LT. AND HT. CO.

A high rate and liberal discount is preferable, as it is what they get off the bill, rather than the net bill, which impresses consumers. FRED. B. SHARPE.

A high rate with liberal discounts is best, as it enables you to favor desirable customers. C. C. GILES.

In regard to which is preferable—high rate per kw-hour with liberal discounts or low rates with small discounts—I think that, so far as the merits of the two rates stand, one is about as advisable as the other, but that neither is as equitable as a low rate with a readiness-to-serve charge and no discounts. If one or the other of the above meter rates is charged, the rate with large discounts would probably appeal to people in general more than would the one with small discounts, and would probably be an incentive to new business. A high rate with large discounts may resolve itself into the same net price as a low rate with small discounts. C. W. HUMPHREY.

A high rate is preferable with large discounts. Rates and discounts should be in decimals of 100. Example: Base rate, 20 cents per kw-hour; discount, 10, 20, 30, 40, 50 per cent, etc. This makes easy the task of computing bills when compared with the 17 cents per kw-hour with nine per cent discount. The first rate allows of a mental computation, while the last requires a rate sheet or resort to a pencil.

GUY C. GUM.

High rate.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

We think it is preferable to offer the low rate with a small discount, as our experience has shown that the lower figures more generally appeal to customers than does a high rate with a liberal discount, the rate naturally being the figure that is first considered by a prospective customer. . P. GOSSLER.

It is impossible to give a specific answer to this question, as the conditions of electricity supply and cost of production vary so much from place to place that it is impossible to make any general statement as to the best system under which to formulate the charges for current and which would apply to all conditions. J. W. L., JR., N. Y. ED. CO.

No. 204.—What is the proper method of charging for exhaust-steam heating?

The proper method of charging for steam heat is by condensation meter, or possibly a combination of flat rate and meter charge. PEORIA GAS AND ELECTRIC CO.

I believe exhaust-steam heating should be sold in the same way that electric current is sold. A fixed charge should be made on the basis of maximum demand, and in addition to this charge the steam condensed should be measured by a meter and charged for at a low rate per 1000 pounds of condensation.

H. S. RUSSELL.

By meter.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 205.—What position is being taken by central stations generally with regard to customers putting on 2-cp and 4-cp lamps? Does it pay to give free renewals?

We believe central stations should furnish their customers anything they want in the shape of lamps, but we do not at present furnish free lamp renewals, and there would be some question in regard to furnishing 2-cp and 4-cp lamps free of cost to the consumer, except in case of sign or decorative lighting where quite a number of them would be used.

E. E. LARRABEE.

We furnish free renewals, and believe it is necessary for a company to do this in order to get the best results. I recommend small lamps for use in some places, and we carry in stock 4-cp lamps for exchange. F. ELLWOOD SMITH.

We do not give renewals of less than 8-cp lamps; we can not carry so many different kinds in stock.

GEO. B. LAUDER.

Small lamps are seldom used where it is very essential that their efficiency should be maintained. I renew no lamp of less than 16-cp. E. S. BOSWORTH.

Free renewals, so far as our experience teaches, should be confined to standard sizes of lamps—8-cp, 16-cp and 32-cp. Our experience has been that lamp-makers would not bind themselves in any way as to the life and efficiency of 5-cp, 4-cp and 2-cp lamps (selling at the same price as standard sizes of 8, 16 and 32 candle-power), and lamps of these sizes were found to be very short-lived or else they consumed six, eight, and even nine watts per candle-power; on the one side involving undue expense for lamps compared to revenue earned, and on the other, trouble and dissatisfaction on the part of the consumer. Specially-made lamps of small candle-power can be bought at a price considerably in excess of that of the standard sizes, which are, as a rule, of very good efficiency; these, as well as the turn-down lamps, we sell to our customers when required, at a price approximating cost, believing that we should help our customers to supply their special needs at the lowest possible prices without loss to ourselves. For lettered sign work, specially-made small candle-power lamps are desirable in any case. THE SHERBROOKE PR., LT. AND HT. CO.

I should unhesitatingly give a consumer 2-cp and 4-cp lamps. As an illustration: A consumer has a four-light fixture in which four 16-cp lamps are placed. Rarely more than one was used at once. Upon being furnished with 4-cp lamps all were used at once and a better illumination and a better pleased customer were obtained. A pleased customer is a good advertisement. GUY C. GUM.

The customer should pay for all lamps under 8-cp, on account of excessive cost of lamps for number of cp-hours used.
LA CROSSE GAS AND ELECTRIC CO.

In Denver we furnish any size of lamp that the consumer wants, but we furnish a lamp of a certain efficiency for each size, which will bring the cost to us the same per kw-hour. This seems to me the most logical way to solve this problem.
C. W. HUMPHREY.

Information gathered by the writer would indicate that the central stations are getting more liberal in the matter of furnishing free installation and renewals of 4-cp lamps, but a comparatively small number are as yet committed to this practice. The question is, how much per kw-hour of output can the company stand for lamp renewals, the smaller candle-power lamps on the same number of hours of life costing much more per kw-hour than the larger ones; but as small candle-power lamps are used largely for display lighting, where decoration is more to be considered than illumination, lamps a volt or two higher than the line pressure can be used with satisfaction to the customer, and this practice will prolong the life of the lamp to such an extent that, taking the advertising feature into consideration, it is excellent practice to install and renew 4-cp lamps free. The present 2-cp lamps, however, are of such high wattage per candle-power that stations that do put out free installation and renewals as low as 4-cp do not feel that they can continue it to 2-cp lamps. JOHN F. GILCHRIST.

No free renewals.
THE EDISON ELEC. ILL'G CO. OF BOSTON.

In lighting with 4-cp lamps, the renewals amount to about four times the cost of the coal required to produce the current, or, in other words, to about as much as all of the other expenses put together. This is such a disproportion that, in my opinion, only exceptional conditions can justify free renewals.

EDITOR.

If the company supplies electric current without regard to the lamps, it would seem to have little control of either types or candle-powers of lamps used by its customers. If the renewal of lamps is included within the price for current, it would then seem proper to limit the size of such renewals to, say, eight candles, so as to confine within reasonable limits the cost of renewals per kw-hour. Lamps of four candles are in some instances desirable for signs, show-case and window lighting, but the efficiency should be so lowered as to maintain about an even lamp life and thereby an even kilowatt cost for renewals. A fair ratio seems to be if 16 candles consume 50 watts, to allow 30 or 32 watts for 8 candles and 20 watts for 4 candles.

"Free Lamp Renewals" is only a term, as the cost of renewals, if it is not, should be added to and included within the price for current. Because of the necessity for expert knowledge of the lamps when purchasing them, and the desirability of frequent renewals when lamps become blackened, to maintain a high standard of illumination, it seems desirable—unless there are other controlling considerations—to make the lamp renewals through the supplying company.

A. W., N. Y. ED. CO.

From the following table of life and the cost per kw-hour for lamp renewals, it will be seen that low-candle-power and sign lamps, in all except a few sizes, are profitable to supply on the free-renewal basis. In making this statement I assume that so long as the cost per kw-hour for renewals does not exceed that of the 16-cp, 3.1-watt lamp—which is about .75 cent per kw-hour—it would be profitable to supply low-candle-power and sign lamps on the free-renewal basis.

With low-candle-power lamps in the Edison standard efficiencies, it would appear that the regular bulb 4-cp, 5-cp and 6-cp lamps of an efficiency of four watts per candle and lower, would be supplied on free renewals at considerably less cost than the regular 16-cp lamps. The cost of the 4-cp and 6-cp lamps is exactly half that of the regular 16-cp, so there should be no doubt that for such lamps the cost per kw-hour will be no greater than for the 16-cp, 3.5-watt lamps, which some stations are still using.

In the lamps made up in the sign bulb, which is considerably smaller than the regular bulb, the 2-cp is below the cost of the 16-cp, 3.1-watt lamp, and the 4-cp is slightly in excess. In general, the question can certainly be answered in the affirmative for free renewals in low-candle-power and sign lamps, especially when it is considered that sign lamps are, as a rule, used in groups, making a total load of considerable size and value.

TABLE SHOWING USEFUL LIFE AND COST PER KILOWATT-HOUR FOR RENEWALS IN LOW-CANDLE-POWER AND SIGN LAMPS

Regular SS-17 Bulb (2⅛ Inch, Pear-Shaped)

Candle-power	Efficiency	Total Watts	Hours Useful Life	Cost per Kw-Hour for Renewals at 18c. per Lamp
4	4.87	19.5	2400	.4 c.
5	4.2	21	1240	.7 c.
6	4.34	26	1745	.4 c.
6	3.73	22	745	1.12c.
Sign Bulbs ($\frac{1}{34}$ Inch, Pear-Shaped)				
2	6.5	13	2260	.6 c.
3	4.87	14.61	680	1.8 c.
4	4.87	19.5	960	1. c.
5	4.2	21	480	1.8 c.

FRANCIS W. WILLCOX.

No. 206.—What success are central stations having in pushing motor-driven ice-making and refrigerating plants for saloons, restaurants, markets and residences?

We have been having good success in using small motors for the class of work mentioned in this question. At the price at which we are selling current, it is quite a saving over apparatus of that kind driven by steam.

WALTER L. MULLIGAN.

The use of motor-driven ice-making and refrigerating machines has but just begun to assume much importance in the operation of central stations. I believe that it is destined to be one of the most satisfactory classes of business for which central stations can cater. I know of no unexploited field for the sale of central-station current which seems to offer better possibilities at the present time than the one here alluded to.

There has been a very marked advance in the art of producing refrigeration on a small scale within the past two years. Machines have been and are being made, and will no doubt very soon be on the market on a commercial scale, which, combining simplicity, reliability of operation and low cost of maintenance, will prove very attractive to the owners of creameries, restaurants, butcher shops, apartment houses, dispensers of temperance beverages and ice-cream, as well as to the better class of private dwellings I anticipate a great advance in this particular business during the coming year or two. I think all central stations would do well to foster this class of business as much as they can.

There are a good many machines being operated by motors throughout the country, but I have no information at hand, except in isolated cases, regarding definite results. I know of one machine in Hartford, Conn., that has been in operation about two years, where the proprietors of a creamery claim that with electricity at three cents per kw-hour and cooling water at 12 cents per 1000 gallons, the cost of their ice bill is cut nearly in half, with all the attendant advantages of freedom from slop, moisture, and the carrying through their store of a large quantity of ice each morning. FRED. M. KIMBALL.

No success here.
THE EDISON ELEC. ILL'G CO. OF BOSTON.

Motor-driven refrigerating plants are in successful use in Denver, although they are not extensive as yet. One meat market here has a one-ton ice machine which maintains a refrigerating room of 2000 cubic feet capacity at a temperature of 30 degrees for 24 hours. The motor consumes on an average about 425 kw-hours per month. C. W. HUMPHREY.

Motor-driven refrigerating plants are not as yet extensively used. There may be as many as a dozen operating in New York city—some having automatic or thermostatic control by which the temperature variations are limited to as few degrees as may be desired. The load and use factors are so high that a low kilowatt price must be made to compete with steam or the iceman. It is generally understood that an electrical horse-power or a horse-power and a quarter, is the equivalent of a ton of ice effect, that is, a ton of ice melting in 24 hours.

A. W., N. Y. ED. CO.

No. 207.—Is it to the best interests of small companies to do a wiring business?

We think it surely is for the best interests of the small companies to do a wiring business, provided they do the work as it should be done. We do not consider inside wiring especially profitable, but we do only first-class work.

E. E. LARRABEE.

Everything considered—no. We tried it and gave it up. It is usually a feast or a famine in the wiring business; the men are worked to death one day and idle the next. The customer expects too much of the company if it does wiring. The contractors get angry. The company is held responsible for defects in the wiring, etc. There is much to be said in favor of the idea, as it probably induces some new business. Our idea is that a strict account of expense will show that the business costs too much for the benefits derived. We don't want to undertake it again. It requires a large and varied assortment of supplies, etc., and unless combined with the usual other lines taken up by contractors, it is a financial failure. Of course, the benefits derived may be indirect and not easily determined. We went into it because the local contractors were doing miserable work. We raised the standard of work greatly. It is often desirable to have control of the wiring of a city or town, so as to insure good work, but the sum total of our experience is—keep out of it.

GEO. B. LAUDER.

Being a small company, we find it necessary to do wiring, but we prefer letting it out to other parties. We have been doing it for our customers at cost. We believe that if other parties were doing the wiring we could get more business through the increased effort to get wiring.

S. S. INGMAN.

We believe it is for the best interests of small companies to do a wiring business. Such companies are usually located in some small town more or less remote from a city, and it is practically an absolute necessity for such companies to have in their employ a man capable of taking care of any small and frequent or urgent wants of its customers. Having such a man, it might be considered desirable for the company to do a wiring business; for, in the nature of things, it would not be very large, and could be done at times when such a man had no other work to do. Moreover, if the company does do such a business, it acts as a check on city contractors, who might be disposed to charge higher rates for work that they might get in small towns.

CHARLES G. BILL.

A man can, I think, solicit business to better advantage if he is prepared to give figures on installation. Many persons conducting a wiring business in small towns are irresponsible, and it is to the advantage of the station that all customers get fair and courteous treatment, reasonable prices, and an arrangement of lights convenient and effective; last, but not least, a safe job. Few small towns support an inspector.

E. S. BOSWORTH.

It is generally necessary for a lighting company to do wiring in order to prevent contractors from charging exorbitant prices and thus preventing people from putting in lights.

C. C. GILES.

Yes; it fills in odd time for wiremen and guarantees satisfactory work for a company. FRED. B. SHARPE.

We believe the station should only carry supplies that they may need for their own use: excepting, of course, fuses and lamps, which they would naturally supply.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Not unless an accurate and detailed account is kept of material and labor supplied, and a fair profit realized thereon. Nor should it be done unless outside contractors are unjust and avaricious in their charges. It is well to have a governing influence, and to act as an arbitrator between prospective customers and contractors. The usual practice of small plants is to do their own wiring, but no immediate financial benefit is ordinarily derived therefrom, excepting the provision of a new patron and a gain thereby in the sale of current. GUY C. GUM.

For reasons best known to ourselves, we do not do wiring, although, generally speaking, we think it would be wiser to do it.

LA CROSSE GAS AND ELECTRIC CO.

I believe it is to the best interest of any small company to do wiring, to insure to consumers of the company a first-class job at a reasonable figure. There is no reason why wiring done on such a basis should antagonize any supply company that is engaged in the same line of business.

P. A. BERTRAND.

We realize that there is some objection to the electric-light company's doing wiring, but from our experience we are sure that the advantages are greater than the disadvantages. It is necessary for all lighting companies to keep an outside man to look after the lines and equipment, and this man with a helper can do all necessary wiring in a small city. Our experience has been that it is necessary to do house wiring at as low a figure as possible, in order to induce people to begin using electric light, and no one making a business of wiring could afford to do the work at as low a figure as the electric-light company. Another consideration is that when the lighting company controls the wiring it will have it done in a safe manner, while if the work is done by some one having no interest in the lighting business, it is probable that a great deal of unsafe work will be done. We believe that in cities of 10,000 population or under, all the wiring should be done by the lighting company, or under its supervison, unless there be a competent city electrician.

F. L. WILLIAMSON & CO.

The writer believes that it is; although not to the exclusion of the outside contractor, whose friendly feeling and co-operation should be encouraged in every way. However, much profitable business can be obtained by the central-station man when small concessions can be made in certain classes of wiring, and when extremely prompt execution of wiring work can be promised, which is impossible unless the station has at least a very good control of the wiring business. Furthermore, the wiring department of the lighting company, properly used, tends to prevent its cumstomers from being charged unreasonable rates for construction work. JOHN F. GILCHRIST.

The best interests of the supplying companies seem to demand the development of as many strong competitive wiring and general contracting concerns within its territory as is possible. To secure this result it may be necessary for the company itself to remain out of active competition. The company, however, should always be ready to enter into competition to maintain a fair standard of prices, and thus prevent by excessive charges improper restriction of its growth. There are some territories in which strong contracting firms do not exist, and there it would seem desirable for the supplying company either to assist in the development of weak concerns and thus make them strong, or to deal directly with the public itself. Competent and resourceful contracting agencies are absolutely essential to a supplying company's proper growth.

A. W., N. Y. ED. CO.

No. 208.—How far should a station go in the handling of supplies where there are wiring contractors in a town?

Local conditions govern this greatly. There are some supplies that a company ought to furnish: Lamps, fuses, fan motors, etc. I believe that the contractors should be given the supply business just as far as possible. I know of nowhere to draw the line, but we give the contractors all the business that we consistently can. GEO. B. LAUDER.

We believe that small stations should handle the supplies for wiring and furnish them to contractors practically at cost, so long as they get the business. This keeps the station very well informed of what the wiring contractor is doing.

S. S. INGMAN.

We carry a small line of wiring supplies and wire to accommodate the small wiring contractor, and charge just enough profit to cover the expense of doing so.

LA CROSSE GAS AND ELECTRIC CO.

The station should handle as few supplies as possible when there are general contractors in town. W. S. BARSTOW.

A central station should go into the wiring business far enough to insure to its customers first-class work at reasonable rates. The extent necessary to bring about this result will depend very largely upon local conditions. In case satisfactory arrangements can be made between the wiring contractors and the central station, it may be advisable to furnish no wiring or supplies at all. The one object that should be kept uppermost in the mind of every central-station manager concerning wiring and scale of fixtures, is to insure his customers the requisites for first-class work. P. A. BERTRAND.

Stations should handle such goods as are not likely to be kept in stock by local dealers. Heating devices, fans, motors, fancy shades, and such wiring fittings as are only occasionally required, are among the supplies the average station should keep in stock. It is good policy to encourage the local wiremen by carrying a small stock of wiring material, which will often enable them to complete a job without vexatious delays—vexatious to *your* customer as well as his. EDITOR.

For the same reasons that it seems desirable to have strong contracting firms within the supplying company's territory, it also seems desirable to encourage the development of supplying agencies. However, this is less important, as the contractors can purchase even at a distance, and the supplying companies can carry such supplies as their customers demand.

A. W., N. Y. ED. CO.

A central station should control the wiring and construction work just far enough to secure: First, the maximum amount of lights and apparatus connected; second, good work in accordance with the Underwriters' rules, that this part of the service may not react upon the lighting company; and third, moderate prices for such work to the consumer.

YOUNGSTOWN CONSOL. GAS AND ELEC. CO

No. 209.—Should not central stations regulate, to some extent at least, the prices charged by wiring contractors?

We believe central stations should regulate the price charge by wiring contractors, and think this can best be done by refusing to furnish current to any installation not thoroughly tested and inspected by the company and approved by the Board of Fire Underwriters. We believe this would keep out the cheap contractors and improve the quality of all work of this nature to a very great extent, as we feel that all inside work should be done in the best manner. E. E. LARRABEE.

This is a matter of local conditions. If the contractors do poor work, or ask too much for the work, a central station would be justified in going into the supply business or in doing wiring. I suppose a central station is justified in looking at the matter coldly, and doing what it thinks will be the best for its ultimate income, but I believe that the contractor has some rights, and should be given all the show possible, provided, of course, that the contractor is all right. I would go to considerable trouble and expense to run a poor contractor out of business, for he can hurt a central station tremendously.

GEO. B. LAUDER.

The writer thinks it very decidedly for the best interests of all concerned that central stations should regulate to some extent the prices charged by wiring contractors, and more particularly that they should have something to say with regard to the *quality* of the work. Otherwise, there may be excessive drop, resulting in poor light, or fires resulting from defective workmanship, both of which will in a large measure bring blame upon the central station. While it is expensive and difficult for the central station to inspect all the work as it is being done, I think that the use of a blank (somewhat similar to Blank No. 1 hereto appended) will greatly assist in maintaining the quality of the work. This blank can be improved somewhat, as upon it the contractor should state that he has wired certain premises in accordance with the rules and regulations of the central stations or of the insurance exchange, or both, and that he will, at his own expense, correct any work not found up to the required standards.

We have also tried Blank No. 2, and have sent the accompanying circular letter to contractors:

NORWICH, CONN.........................190

NORWICH GAS AND ELECTRIC CO.,

Gentlemen:—

We have wired the premises occupied by

M..

Location, No..Street,

or ....

as follows, viz.:—

....

....

....

The work and all the wiring incident thereto is completed in accordance with the rules of the New England Insurance Exchange.

We agree to make any change that the New England Insurance Exchange may request or order.

Signed...

NORWICH, CONN.,........................190

To NORWICH GAS AND ELECTRIC CO.:

We are about to wire the premises

No...St.

for M.. Please advise with us regarding best place for leads to come out.

We have wired for....................additional incandescent lights

on the premises No...St.

for M..

Signed..

CIRCULAR LETTER SENT BY COMPANY TO CONTRACTORS

"GENTLEMEN:

"For the benefit of the service and for the protection of our customers,

we have adopted the following rules in connection with wiring intended to be connected to our circuits:

Unless these rules are complied with, we shall refuse to make connections:

(1) Proper notice must be sent in advance of work that is to be done, so that we can meet you and consult about the location of leads; also notice must always be given in advance where new lights or more power are added for customers of ours.

(2) The rules of the National Board of Fire Underwriters will govern, and will be the standard by which we shall judge work when making inspections, except as follows:

(3) Knife-switches of suitable size must be used at the entrance to buildings.

(4) Flush-switches must be placed in an iron box.

(5) A maximum drop of not over two per cent will be allowed between the main cut-out at entrance and any lamp with all lamps burning.

(6) All defects to which attention is called must be remedied within two weeks.

"We trust it will be appreciated that these rules are adopted with a view to securing good and uniform work, and we hope they will prove to be for the benefit of all concerned."

ALEX. J. CAMPBELL.

When the central stations do a wiring business, the competition will bring the price to the proper point.

FRED. B. SHARPE.

It would seem desirable for the central stations to keep aloof from any attempt to regulate the prices of the contracting firms in their territories, unless, as previously suggested, they find the prices maintained are so high that proper growth of the company is prevented. In most instances a word to the contractors upon the subject will be enough to correct the evil.

A. W., N. Y. ED. CO.

No. 210.—Is it economical practice to maintain a storekeeper in a plant of, say, 1000-hp capacity, supplying 300 arc lamps?

We find it to our advantage to keep a man to take account of our stock, and keep track of it as it goes out on the different jobs.

WALTER L. MULLIGAN.

We have an output a little in excess of 1000 horse-power, and we have not found it advisable to keep a storekeeper. The amount of saving that a storekeeper would effect in so small a plant would not offset his salary or wages; at least, it seems so to us, and seems to be the general opinion.

GEO. B. LAUDER.

We believe that it would be economical practice to maintain a storekeeper in a plant of any size. With the storeroom accessible to the employees generally, material is certain to be wasted.

S. S. INGMAN.

While theoretically advantageous, the writer regards it as being very doubtful whether it is economical practice to maintain a storekeeper in a plant of the size given.

ALEX. J. CAMPBELL.

Without experience under the conditions named, should say no.

C. S. S., N. Y. ED. CO.

No. 211.—How do you keep account of stock? Will you kindly send forms, if necessary, for complete explanation?

A stockkeeper should be employed by all moderate-sized stations. The accompanying forms show the method used by the Sandusky Gas and Electric Co. When material is received it is entered on the stock card, also when used; therefore, from the stock card a complete inventory can be had at any time.

A. C. BLINN.

Edison Key Sockets

In Stock		Cost Price	Material Used		Selling Price	Material Used		Selling Price
500	G. E. Co. 6/4/03	1485	2	6/4/03	.20			.20
			5	8/4/03				
			10	10/4/03				
			14	10/4/03				

CO. WORK—CHARGE Line Repairs

Material issued to R. Downing
To be used at Col. Ave. and Market St.
For repairs and arc circuit

Am't	Material Issued	Am't	Material Returned	Am't	Material Used	Cost Price	
125	No. 6 W. P. wire.	50 lbs.	No. 6 W P. wire	75	No. 6 W. P. wire.	....	....
12	Insulators.......	......	....	12	Insulators.......	....	....
12	Wood pins......	......	....	12	Wood pins......	....	....
3	4-pin cross-arms.	......	....	3	4-pin cross-arms.	....	
......	....	......	....	......	....	....	
......	....	......	....	......	....	....	
......	....	......	....	......	....	....	
......	....	......	....	......	....	....	....
					Total		

CHARGE West Hotel Co. MERCHANDISE

Material issued to M. White
To be used at Rooms 302, 304 and 306
For West Hotel Co. Contract Price................

Am't	Material Issued	Am't	Material Returned	Am't	Material Used	Cost Price			Selling Price	
8	K. W. rosettes...	4	K. W. rosettes..	4	K. W. rosettes..	....	..	..		...
8	Ed. sockets.....	4	Ed. sockets.....	4	Ed. sockets....	....	..	...	....	...
2	5-amp. snap sw.	1	5-amp. snap sw..	1	5-amp. snap sw..	....	..	...	....	..
100 ft.	No. 18 lamp cord	25 ft.	No. 18 lamp cord	75 ft.	No. 18 lamp cord	....	..	..	..	...
25	No. 5 knobs....	10	No. 5 knobs.	15	No. 5 knobs. ..	....	..	...	..	...
......	....	....	....	......	LABOR........	....	..	...	....	...
......	....	......	....	......	M. White 3 hrs.	....	..	...	....	...
.....	....	.....	....	......	A. Neuchrist 3 "	....	..	...	....	..
					TOTAL........					

We do not keep any running account of the amount of the different kinds of stock on hand. The money value of the stock is kept on debit and credit system, charging it out to the proper job when it is drawn out, and we depend upon frequent inventories for the information as to the amount of different material on hand. Each department receives weekly reports of most active stock in which it may be interested, that is, the amount on hand. We have no forms that would make this matter any clearer.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Having a small plant, I use a "requisition system" of supplies. All materials are kept in a room by themselves, called a storeroom. A storeroom ledger is kept of all materials, viz.: lamps 16-cp, lamps 8-cp, sockets, insulators, lamp cord, and, in fact, all items have a separate account. Upon receipt of material the items are charged in each separate account in this storeroom ledger. Any material taken from the storeroom requires a requisition, and these requisitions are filed in the storeroom when the material is taken out. At the end of the month these requisitions are credited in the storeroom ledger to their individual accounts and the balances brought forward. The first of every year an inventory is taken and the ledger corrected. FRED. M. FRIEDBERG.

Account of stock is kept on stock ledger cards, one for each kind of material. On these cards are kept records of receipts, deliveries and orders. C. S. S., N. Y. ED. CO.

No. 212.—Should stations dip lamps free of cost for their customers, in addition to furnishing free lamp renewals?

I do not think so. We furnish free renewals for 4-cp, 8-cp, 16-cp and 24-cp lamps; for any other style of lamp we charge the customer the actual cost. F. ELLWOOD SMITH.

Stations should be in a position to frost lamps (by dipping) without charge, but colored lights are not in the same class. Revenue producers, as a rule, should be paid for.

THE SHERBROOKE PR., LT. AND HT. CO.

We do not dip lamps, but we furnish the customer with free lamp renewals, and he has to pay the wiring contractor for dipping lamps. LA CROSSE GAS AND ELECTRIC CO.

I think this is a question that each central-station manager must decide for himself. Our company does not use dipped lamps, except in some of the colors; never frosted. The customer in all cases pays the additional cost of dipped lamps over plain lamps in renewals. J. N. BISSELL.

If the company undertakes to make renewals, it seems desirable to give its customers a choice of plain or dipped glass.

A. W., N. Y. ED. CO.

No. 213.—Does it pay to support display rooms?

Our exhibition department has been in operation since the fall of 1899, and, as in other advertising schemes, it is rather difficult to trace results. However, we feel satisfied that this department is accomplishing what it was primarily intended to do, that is, to interest and in some degree educate the public. The attendance has constantly increased from year to year, and we know of a great deal of electrical apparatus that has been sold to parties who have become interested in it by seeing it in operation in this department. It is not intended as a general advertisement of the company, but more as a method of informing the public of the great variety of useful ways in which electricity can be applied. We advertise it quite vigorously in the papers and by other means during the autumn months, and are satisfied that up to the present time it has been a paying investment. Other large lighting companies are following suit and preparing to open similar departments.

LA RUE VREDENBURGH.

Generally, yes. W. S. BARSTOW.

The expense of maintaining display-rooms is purely an advertising item, and, as in all forms of advertising, it is a little difficult to say to just what extent it is of pecuniary advantage; but the electrical business is much like any other business, and the inspection of the goods to be sold or the results to be obtained with them certainly attracts customers and helps business. JOHN F. GILCHRIST.

Undoubtedly. Good advertising in any form seems to pay.

A. W., N. Y. ED. CO.

No. 214.—Will you give a list of articles desirable for an attractive display for the office of a lighting company, together with scheme for arrangement?

A collection of Nernst, Meridian and candelabra lamps, together with fixtures of a neat design, to be mounted on a display board of some dark material; the different lamps to be controlled by different switches, such as a three and four-way double and single-pole of flush, snap and push style, all the current passing through a wattmeter with a glass case, so that the advantages of the different types of lamps and systems of control can be demonstrated, with the amount of current consumed by each.

H. M. BEUGLER.

Different forms of illumination, such as lamps at the corners of a panelled ceiling; lamps on the cornices; lamps behind moulding, giving illumination by reflection; a few small wall brackets of neat design; portables for the reading-table in the library or in the bedroom; one or two examples of special fixtures or candelabra for the dining-table; variety of shades for the home, office, store, and show-window; the silvered glass reflectors for the show-window and the large diffusers for arc lamps are important examples; one or two examples of switch and panel boards for centering control of installation. In the larger centres, an example of an electric elevator with the automatic attachment for residences; show-window fixtures, including a window rod by which the position of lamps may be changed to fit the dressing of the window; and electric refrigerating plant, automatically controlled, including the icebox within which articles are maintained at the temperature desired. Various applications of motors, including the sewing machine, more especially for manufacturing; a machine tool for shop work, and one or two examples of special application, more especially intended to indicate the range at which electric power may be adopted for all mechanical purposes; ventilating fans; various sizes and kinds of incandescent lamps, including colored and candelabra lamps; decorative systems, such as the Elblight; signs, ornamental and plain; heating and cooking appliances in service ready for immediate use; arc lamps of various types and with a variety of shades. The exhibition room should be so divided that the lighting effects may be shown without daylight interference.

A. W., N. Y. ED. CO.

No. 215.—How is plant or betterment account taken care of in the large stations?

By an elaborate appropriation system; each appropriation being authorized by the president, and every order drawn under an appropriation being approved by proper officers and charged against the appropriation.

Plant or betterments are generally charged to construction. Such charges are closely scrutinized, and only those expenditures which cover a *bona-fide* addition to the plant are so considered. This company employs the job system in its construction work. A written description of every bit of work planned, with an estimate of the cost, is submitted upon proper form to the management, and after approval is signed by the executive and given a working number. The account to be charged is determined at the same time. No expenditures can be charged to construction except through the job system; hence, at the end of any period, the company is enabled to make a construction exhibit by general accounts and also by specific jobs under each general classification. H. M. E., N. Y. ED. CO.

No. 216.—How do you figure depreciation?

We think that a fair depreciation is 15 per cent for the first year and 10 per cent thereafter on station apparatus, boilers and engines. On lines and poles, 10 per cent for the first year and five per cent thereafter. We know that this is considered rather low, but if the equipment is maintained in first-class condition we think these figures safe. The apparatus now built should be more stable than any made in past. S. S. INGMAN.

Average about eight per cent, varying from two per cent on underground construction to 10 per cent on engines and generators. W. S. BARSTOW.

Have no means of figuring depreciation. We charge all actual repairs to the repair account, and transfer an arbitrary amount annually to a reserve for maintenance account. This account is charged with original cost of any property disposed of.
THE EDISON ELEC. ILL'G CO. OF BOSTON.

Depreciation does not necessarily imply reducing the book value of the assets to the present or cash value. One theory is to set aside out of the earnings each year a sum sufficient to maintain the plant at its maximum working capacity. It is a fact that, in addition to the ordinary repair and renewal expenditures, which, it is assumed, are made as required, there is a depreciation—the results of which do not become apparent at once. This method would, therefore, be to appraise the active plant—both generating and distributing—at the replacement value at the beginning of the period, and charge each year on the values so obtained the annual rate of depreciation that the best experience agrees upon. The rate per cent necessarily varies according as to whether the item to be depreciated consists of boilers, engines, piping, generators, electrical apparatus, street conductors, service devices, etc. The amount of depreciation thus obtained should be reduced by the amount expended for repair and renewal of the apparatus, upon the theory that repair and renewal arrest depreciation to a corresponding extent. An equivalent sum should be appropriated out of the net earnings at the end of each year; the said amount being credited to depreciation fund, and this fund should be charged with replacements as the same are made. H. M. E., N. Y. ED. CO.

No. 217.—What is the best method for control and disposal of scrap?

This is a subject of great importance, not only on account of the very considerable waste that is frequently met with even in large plants, but also because of the demoralizing effect on the men of any carelessness in the handling or disposition of scrap material, which frequently has considerable value. For some inscrutable reason men are apt to be much more wasteful proportionately with large quantities than with small, and it is therefore best to keep an open receptacle of moderate size for daily accumulations, transferring its contents from time to time into a larger one provided with lock and key.

A careful, competent man should be detailed to attend to this periodically, sorting out the contents of the smaller box and scraping only such stuff as can not be made use of without unjustifiable expense. When there is a sufficient amount on hand in the large box, the junk dealers should be called on to bid on it. Don't allow valuable space to be cluttered up with old instruments, fuse-boxes, or burned-out transformers of obsolete type, and the like, which will never be salable except as scrap, but don't allow anything to be scrapped unnecessarily, such as sockets or fittings lacking only some part to make them complete. Transfer such goods from the small scrap-box to a special bin in the storeroom, and insist that with this exception the storeroom be kept clear of everything but perfect goods. Fitting up incomplete articles makes a good rainy-day job for apprentices and helpers. EDITOR.

No. 218.—Has the Doherty rate been applied to power consumers; if so, what is the usual basis of computation?

The Doherty rate system has been applied to power users to a limited extent. The basis of charging in one large city is $12 for each consumer plus $24 per horse-power demanded plus two cents per kw-hour for current. In another city the charge has been placed at $12 per consumer plus $27 per horse-power demanded plus three cents per kw-hour for current. One large central station uses the following system of computation to indicate what kilowatt rate they can afford to offer to different classes of consumers. They figure the consumer charge at $9.00 per year plus $20 per year per horse-power demanded plus two cents per kw-hour for current. Instead of charging on this basis, they find out what the equivalent kilowatt charge would be and then quote this as the kilowatt rate.

J. F. DOSTAL

No. 219.—Is the Doherty rate of special value to plants of small size (225 consumers) in cities of 3000 inhabitants?

I can not see that the Doherty rate system of charging is of special value to small-sized plants any more than it is to large-sized plants. It is simply a rational system of charging, which, without further effort, discriminates between profitable and unprofitable consumers. Aside from the question of equity, it has the advantage of making bills more uniform throughout the year by lessening the heavy winter bills and increasing the light summer bills. This has resulted in lessening complaints from consumers, as the greatest dissatisfaction that develops with consumers is generally due to a rapid increase in lighting bills in the fall months. It also has the advantage of developing uses of current without any great concessions in revenue. Assume that a station is selling current at 15 cents per kw-hour and a change is made to the Doherty rate system of charging that would be equivalent to a general reduction to 13 cents per kw-hour. Now, a reduction from 15 cents to 13 cents per kw-hour would not encourage the lavish use of current, while with the Doherty rate system of charging the rate for current would only be five or six cents per kw-hour, and such a marked reduction on additional current can not help but discourage the rigid economy that now prevails among some consumers, and can not help but encourage the liberal use of current for long-hour lighting, such as show-windows, signs, and similar purposes. This additional use of current will cost the company much less than the average use of current, and as a rule it will not add anything to the company's expense except additional boiler fuel. J. F. DOSTAL.

No. 220.—When meters are used by an electric-light plant, should there be a minimum rate paid irrespective of the meter readings; if so, what should the minimum rate be?

Yes; $1.00 per month for one-kw capacity or less in business places, and two-kw capacity in residences, as demand charge, yearly contracts, adding at the same ratio for increased capacity demand. GEORGE L. COLGATE.

Yes, we charge 15 cents per light per month.
FRED. B. HUBBELL.

I believe the only equitable system of charging is to provide for payment of fixed expenses incurred by the consumer regardless of current generated, but I recognize that the terms of a franchise often make it impossible to insist upon such a system of charging for all consumers. We all know that there are certain expenses which bear no relation to the amount of current consumed, such as cost of reading meters, making out bills, collecting, transformer core loss, meter shunt loss, etc., etc. These expenses are often in almost direct proportion to consumers' maximum demand. This is especially true of the core loss of transformer. I therefore think minimum bill should be based on number of lamps demanded. One city charges the consumers it is supplying on meter basis, a minimum rate of not less than $1.50 per month nor less than five cents per month per lamp installed. HENRY L. DOHERTY.

A minimum rate should always be charged on meter service to guarantee an income to cover repairs and depreciation. Below please find the rates as charged, and the minimum in each case.

MONTHLY RATES FOR METER SERVICE

Watt-hours	Rate per 1.000 Watt-hours	Minimum Charge
20,000 or less	15 Cents	$1 00
Over 20,000 to 50,000	13½ Cents	3 00
Over 50,000 to 100,000	12 Cents	6 75
Over 100,000 to 200,000	11¼ Cents	12 00
Over 200,000	9¼ Cents	22 50

Meters will be rented to consumers at 25 cents per month. A charge of $1.00 will be made for installing meters, which will be rebated after six months has been paid.

The minimum charge in every case covers the meter rent.

FRED. M. FRIEDBERG.

We believe that a minimum rate should be paid. Our minimum rate is $1.00 per month, and this is charged whether they use five kw-hours or nothing.

F. ELLWOOD SMITH.

There should be, for all customers, a minimum rate equivalent to standing charges against the equipment that their installation demands. In our business we own the meters and arc lamps, and make a minimum charge of $2.00 per arc lamp, 10 cents per 16-cp incandescent, but with no minimum less than $1.50 except in case of residence using six lights or less, where we make a minimum of $1.00.

F. L. WILLIAMSON & CO.

No. 221.—Should the minimum rate be the same in a summer resort, where one-half to five-eighths of the lights are used for three or four months in the summer by customers whose winter bills are not more than 10 per cent of the summer bills; if not, what should the minimum rate be in such a town?

Increase rates 50 per cent for summer load.

GEORGE L. COLGATE.

There are two plants operating in this town. Both of them charge summer customers (about 50) 25 per cent more than 12-

month customers. The other company initiated this practice and it continues.

THE SOUTHAMPTON ELEC. LT. CO.

No. 222.—Is it good practice to charge summer customers, or three and four-month customers, the same rate as 12-month customers; if not, what is the best method of charging for such customers?

Three and four-month customers should always pay more than 12-month customers. The best rates depend on conditions, but our usual practice is to allow the latter about 25 per cent better discounts than the former. EDITOR.

We make no difference.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 223.— Will it not be necessary to discriminate in the rates for the different types of illuminants where the operating company owns lamps and furnishes renewals, if the cost of maintenance per kw-hour varies greatly?

It is desirable to discriminate in the rates for illuminants of different kinds that vary greatly in cost of maintenance, but it is not always practical. For instance, the constant-potential arc lamp, which costs considerably more for maintenance than an equivalent capacity in incandescent, is generally used for fighting Welsbachs, or for catching some customer who *must* have cheap light, and, in consequence, where there is any difference in meter rates, those for arc lighting are usually the lower.

EDITOR.

We should say that the simplest way is not to furnish special types of illumination unless the customer pays something for the lamp.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 224.—In changing from an overhead to an underground system, what is the best practice with regard to charging for new underground house connections?

You will probably find that it will be impossible for you to charge customers for changing to underground connections without arousing antagonism that will cost you more in the long run

than the cost of connections. If it is possible to do so, charge them for all labor and material used. If not, make an average charge per foot of service line. This will, of course, be too high in some cases and too low in others, but it has the advantage that the customer can know in advance exactly what he will be called upon to pay.
EDITOR.

We have never made any charge for new connections of this kind.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 225.—What has been the experience of water-power plants with the maximum-demand flat rate, controlled by a Lacey controller, or similar device?

An experience of about six months with the Lacey controller would indicate that it furnishes the best means thus far put on the market to deal with flat rates. As to its reliability in the matter of keeping in adjustment, our limited experience will not allow us to state, as we have not yet made a systematic inspection of it. That those set up thus far have remained in adjustment is likely, as we have had no complaint of the limit of any customer having been cut down. Common sense would, however, dictate that this instrument, the same as any other device for measuring current, should not be allowed to go for an indefinite time without inspection and test. Inspection in September, November and January, and probably in May, would be sufficient.

Its makers would add to the popularity of the instrument by getting up a convenient and portable apparatus for verifying the controller without disturbing its setting or connection. A testing box equipped with standard lamps or some other suitable load, with an indicating wattmeter or an ammeter and voltmeter attached, and a connecting device that would admit of the outfit being quickly attached to the circuit near the controller, would probably fill the bill.

In setting the controller it must be adjusted to carry the load contracted for at the extreme voltage to which the circuit is subjected, otherwise the controller will strip when the voltage rises without having more than the rated number of lamps in circuit. Our average setting allows about 60 watts to a 16-cp lamp.

One effect of the use of the controller is to bring home to the average customer that there is a wide range in the efficiency of lamps. Our contract is made in terms of 16-cp lamps, government standard, and the customer distributes his current to his own best advantage.

THE SHERBROOKE PR., LT. AND HT. CO.

No. 226.—What is the relative value of good gas per 1000 feet for illuminating purposes, when used with the best Welsbach burners, as compared with electric current at 15 cents per kw-hour, used in 3.5-watt incandescent lamps; the customer buying his own mantles, chimneys, etc., but the incandescent lamps being furnished free by the electric-light company?

(Answers to question No. 226 were read in executive session.)

No. 227.—How far should electric-light and power companies go in the matter of statistics?

Our idea is that individual records should be kept for each detail of the business when the results therefrom show a saving over the expense of recording these data. We favor a card-system record for each branch of operation, which will show all the points necessary to give a complete history of the case, for the purpose of comparison at stated periods. Our experience with this plan, so far as we have carried it, is that the results have been very gratifying, more than paying for the time and expense necessary to keep them up. Such records, properly kept and inspected, are an incentive to develop the best there is in an employee; many of whom become more or less careless through apparent indifference of the responsible parties.

S. S. INGMAN.

This is a difficult question to answer in this form, as it would depend almost entirely on the size of the company and the territory in which it was operated.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 228.—Does the use made of daily load diagrams of station-generated and substation-distributed outputs warrant their cost?

All practical objects in keeping load diagrams would be fully served by typical diagrams of some one day out of each week, or even one day out of every month. EDITOR.

We believe it does.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 229.—What is the best method of meeting gas-arc and Welsbach competition with gas at $1.25 per 1000 feet?

Multiple alternating arcs on meter, the company furnishing lamps and charging minimum of $2.50 per arc lamp per month, yearly contracts. GEORGE L. COLGATE.

Use Nernst or Meridian lamps on flat rates. These lamps give a much more agreeable light than the Welsbach, in units of about the same capacity, while they have many obvious advantages. Or use inclosed-arc lamps on flat or meter rates. If you can get your customer to try one in comparison with the Welsbach, he will be greatly impressed by the contrast in the color, as the peculiar greenish shade of the Welsbach seems to be intensified by the blue of the arc lamp.

Don't run down the Welsbach, but content yourself with pointing out the good qualities of your own light. Don't try to prove that electricity will be the cheaper of the two, for it won't. Begin your campaign against Welsbachs as the hot weather comes on, and the advantages of fans and a cooler form of illumination become evident. EDITOR.

No. 230.—Would it not be a good idea for the association to establish a bureau of advertising to suggest forms for local advertising to secure business of lighting, power, etc., and to furnish these from time to time to the members? It would also be a good plan, in the interests of the larger stations, for this bureau to keep in touch with capable electricians and other high-class employees.

We believe each town should have its own local advertising bureau, as conditions in different towns might vary materially. It would probably be a distinct advantage if these advertising bureaus of different localities had some means of exchanging ideas.

THE EDISON ELEC. ILL'G CO OF BOSTON.

No. 231.—What methods of advertising and soliciting are found to be most successful in obtaining new business?

Unique and catchy advertisements in local publications, as well as a prominently located show-window liberally stocked and well placarded with interesting information. Automatically operated changeable displays (cut out the red, white and blue lamp "gag") are attractive when attached to some useful appliance. In connection with the above, it is well to have a plausible "buttonholer," who can interest progressive people without exaggeration.

One of the best advertisements, as well as the least expensive, is a well-pleased customer. GUY C. GUM.

A house-to-house canvass and a heart-to-heart talk.
THE EDISON ELEC. ILL'G CO. OF BOSTON.

Of the many methods tried and adopted by our company, we have concluded that the method of circular letters sent out at regular intervals has shown the most noticeable results. About a year ago we sent a series of six large postal cards to all our electrical consumers. The card was gotten up in attractive style, with a cut on one end of the card and the reading matter in a bold handwriting. We called their attention to our rates for lighting and the purposes for which it could be used, and there was a direct and noticeable increase in the sales of current. Next to this, and probably nearly as important, is the personal solicitation. We have our city divided into districts, and a man is assigned to each territory. It is his duty to call regularly on all consumers and find out their needs and endeavor to supply them. We find great advantage in this, in that the solicitor will hear of complaints or imaginary grievances of some consumer, which he is able to straighten out and adjust in a few minutes' conversation and which, if he did not take up and adjust, would lead to trouble and dissatisfaction. We are making it our chief aim, first, to satisfy all consumers, and, second, to increase our sales. Newspaper, street-car and billboard advertising have all been tried and continued and the results from them have been gratifying, but it is much more difficult to locate or realize the results from this class of advertising. We have striven to keep the appearance of our office noticeably attractive. At night it is brilliantly illuminated from the roof to the bottom of the windows. On the roof we have a large electric sign, the reading on which we change continually. All the windows are lighted up and have a constantly changing display of appliances or fixtures. The inside of the office is kept lighted, so that people passing will take notice of it. At the bottom of each window we have a large plate, which is lighted up from the rear, and on this we have advertising sentences. I believe that all forms of advertising or publicity will bring results to a lighting company, but those that attract the attention of the consumer to some definite feature, and that are done in a systematic manner and continued without interruption, will show the best results. We therefore are partial to the system of mail advertising and personal solicitation.

FRANK W. FRUEAUFF.

The best method of advertising is as follows:

1st. Give a good light.

2d. Be courteous and kind; both officers and employees.

3d. Always give satisfaction as far as possible in all departments.

4th. Use a small amount of printer's ink.

5th. Make your charges as low as possible, and do not discriminate in your rates.

As to soliciting; it is a poor policy in small towns. A person coaxed to use light thinks that in so doing he does you a favor. I have found in some instances that a personal letter addressed to prospective users, calling their attention to our lighting, has met with some success, but this, more especially, in having new buildings wired.

FRED. M. FRIEDBERG.

No. 232.—Outside of cultivating a day load by supplying power, what is being done generally toward encouraging the use of summer current by water-power plants?

In the case of this company, in addition to making fans a feature during hot weather, the use of electric irons for household laundry purposes is being pushed as much as possible. Their convenience and comfort in hot weather are continuously advertised. The irons are exhibited and their operation shown at the company's office. The irons are sold and proper connections put in virtually at cost, and in the case of meter customers special rates are made to cover current used in ironing, in the following ways:

To our customers who have been connected for more than one year, all current used during the summer months, from April first to October first, in excess of the consumption for the corresponding months of the previous year, is charged at half rates.

New customers, who have no previous year's record with which to compare, are charged at half rates for all current in excess of 50 watts per day per lamp of their maximum demand, between the first of April and the first of October.

Maximum-demand flat-rate customers whose contracts do not call for sufficient capacity to operate an iron (from 4.5 to five amperes) may have their controllers specially set between the fifteenth of March and the fifteenth of September, by paying a fixed monthly charge for the service.

In this way a growing demand is being cultivated for current for which there was previously no particular call. In the case of the foregoing, however, as in other matters, local conditions vary a great deal, and while the above methods suit the conditions in this place, there might be objections to them elsewhere.

THE SHERBROOKE PR., LT. AND HT. CO.

No. 233.—What is the best method of illustrating the superiority of electric-arc lighting with reference to general illumination, matching colors, etc., in form of circular or card that can be kept prominently before the public? In other words, can a card or circular be printed in several colors; each color labeled, and instructions be printed on the card for viewing same under various lights, noting the difference in appearance under each and in daylight? What colors should be used for best results in comparisons between electric and gas arcs?

In order to bring out prominently the superiority of the electric arc light for color matching and selection, three instruments have been designed, namely, the photochromoscope, lumichromoscope and the parachromoscope. With any one of these instruments a prospective customer can compare the effects of different lights on colored fabrics. For instance, the lumichromoscope is so arranged that the light from four sources, namely, the arc, Nernst, Welsbach and incandescent, fall simultaneously on to the material under examination. Each light forms a patch two and one-half inches square, with a black border separating the squares so as to reduce simultaneous contrast and gradation. Colored plates are being reproduced from these instruments and will be printed in book form. Reduced colored charts will also be printed on small cards, on the reverse side of which will be given general illuminating engineering data for high-class mercantile lighting. The colors that should be used for the most striking contrasts in comparison between the electric and gas arc are violets, blues and yellows, containing a rather small percentage of green. The general color value of arc lights is best illustrated by showing all the principal colors, namely, red, orange, yellow, green, blue, indigo and violet.

The lumichromoscope and parachromoscope will be in operation at the convention. W. D'A. RYAN.

No. 234.—How can central stations best dispose of electrical or other apparatus that is too small for, or not otherwise suited to, present or future requirements?

I would suggest that each individual member—company or corporation—make up a list of such materials on hand as he may desire to dispose of, forwarding said lists to the association headquarters, to be kept on file. When any one is in need of a second-hand engine, boiler, pump, lamp, transformer, or any other apparatus, he could obtain same through the association, thus saving the second-hand dealer's profit to the seller and buyer, both of whom, belonging to the association, would, or should, deal with each other squarely, whereas at present the second-hand dealer asks *Tom* $100 for what cost him $10 and offers *Dick* $10 for what is worth $100, which is one reason why so many small electric-light plants go out of business—having been sucked to death by the jobber in electrical apparatus.

A. C. HOPE.

By bringing their wares before the eyes of the constituency by liberal advertising in the electrical journals; or, better yet, by the National Electric Light Association's maintaining an exchange bureau, open to every central station.

GUY C. GUM.

The best way to dispose of electrical apparatus too small or otherwise not suited, is to print small circulars and mail to such plants as are likely to need the same. Size of plants, and all needed information can be obtained from *Powers' Directory.*

FRED. M. FRIEDBERG.

No. 235.—What is the most equitable method of arriving at the selling price of a small electric-lighting plant which cost $18,000; gross earnings, $6000 per year, increasing all the time; operating expenses, taxes and repairs, $3000; net earnings, $3000. Municipality wants to buy for $18,000—cost of plant. Lighting company wants $30,000, at which price plant would be 10 per cent on investment.

Which is the equitable price, or should some other price be made, and if so, how would you arrive at same?

The only equitable method for arriving at the selling price of an electric-lighting plant is on the basis of the net earnings, as the business the company has spent time and money in working up is quite as much an asset as the apparatus. Estimate the amount of repairs and renewals necessary to put the plant in first-class condition. Capitalize the plant on the basis of a certain percentage of its net earnings, and subtract the estimated cost of repairs and renewals, to arrive at the proper selling price. For example, in the case cited, if the company is capitalized on a 10-per-cent basis, the price would be $30,000, and if $3000 are required for immediate repairs and renewals, the equitable price for the plant would be $27,000. EDITOR.

It is difficult to state what, in all cases, is the most equitable method in arriving at the selling price of a small electric-lighting plant, but the following, in many cases, appears to be fair to both the purchaser and seller. A plant should sell for a sum that would earn a reasonable interest on the investment, and not necessarily for what it cost, for an electric-light business, exclusive of the physical property, frequently represents a great deal of hard labor and careful management and has an intrinsic value.

Assuming six per cent to be a fair rate of income on the investment, and five per cent on the plant cost to be a proper rate for depreciation, add to the cost of the plant, which in this case is $18,000, an amount that will place the property in physical condition so that five per cent on the total will provide a sufficient depreciation fund, and this plant would be worth $31,000, as follows:

Gross Earnings		$6000
Operating Expenses, including Taxes and Insurance		3000
Net Earnings		$3000
Depreciation, Five per cent on $20,000 ($2000 being necessary to put the plant in physical condition)		1000
Surplus Earnings		$2000
Which amount is Six per cent on	$33,000	
Less amount necessary to place plant in physical condition	2000	
Value of property	$31,000	

E. H. MATHER.

No. 236.—Is it a good investment in a small electric-light plant running from dusk to dawn, to install an exhaust-steam-heating system to sell exhaust steam?

The greater part of the heat required from such a plant would be needed during the day when you have no exhaust steam to sell. During the early part of the night you would doubtless have more than would be necessary, but during the latter part you would not have enough. You would probably find that the first cost and the repairs on your steam-heating system would be excessive in comparison with the returns.

EDITOR.

No. 237.—Would it not be profitable for the members of this association to organize a mutual insurance company?

We believe that a mutual fire-insurance company could be organized to cover electric-light plants only, which would be of decided benefit to the members. We are sure that such a mutual company would reduce the cost of insurance very materially and that the experience of a few years would bring out many facts, the recognition of which would be of much benefit to all concerned.

We operate a flour mill, and carry all our insurance in mutual companies. Each company has a regular inspector who visits us frequently and makes a thorough inspection of our property. This inspector notes things that may have escaped the notice of the regular employees and calls to our notice things that need attention. We believe these inspectors are worth to us fully half what our insurance costs, as this is a case where prevention is far better than any possible cure that fire insurance may be. We believe there should be several classifications, made according to the relative risks.

F. L. WILLIAMSON & CO.

We should think it would not be profitable.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Mr. J. D. Gerlach, manager of the Chester Light, Water and Ice Co., of Chester, Ill., has had some valuable experience with such an organization as is suggested in question 237, which he will be glad to communicate to any member who is interested in the matter.

EDITOR.

No. 251.—Will you describe a cheap and convenient method of reproducing maps and other drawings where there are no facilities for blue-printing?

I have frequently made one reproduction by the very ordinary method of using carbon paper and going over the drawing with a stylus. This, however, is very laborious, and can hardly be recommended. GEO. B. LAUDER.

We have used with a great deal of satisfaction a kind of gelatinous copying pad for copying maps and parts of maps as desired, the copy being taken with special ink made for this purpose, care being taken not to blot the ink, as it does not erase easily. When the copy is dry, use the gelatinous copying pad and make as many as 50 copies from the first one impressioned, when this can be cleaned off and the original placed again, allowing it to remain some time longer on the pad, when another lot of about 50 copies may be secured. We use a large sheet of glass laid on a frame to take the place of a drawing table, under which is a bank of incandescent lamps, which allows ample facilities for taking a copy from any map or blue print. The map and the blank paper of good quality are held in place by numerous paper-weights, the room being darkened in making the copy from the original. The use of white paper instead of blue gives ample facilities for several colors of ink, if necessary, as well as the use of pencil to show the work desired to be laid out of which a record is to be kept.

E. B. GREENE.

We know of no way except to trace the map or drawing. Facilities for blue-printing are so simple that we can not see any reason why they should not be present wherever there is any need for them.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 252.—Why should electric-light carbons take such a high freight rate; or, rather, why should they not take the same rate as other commodities of equal value and risk?

The question of excessive freight rates on electrical apparatus was for several years in charge of a committee of the association, of which Mr. James I. Ayer was chairman. In spite of all efforts to obtain a reasonable reclassification, it was found impossible to accomplish anything. A statement of the work of the committee will be found in the proceedings of the conventions of 1899 and 1901.

The attitude of the railroads is sufficiently indicated by the following letter from the Central Traffic Association, which represents the eastern lines :

"In reply to your inquiry I have to advise you that the Classification Committee is of the opinion that the rating in question applying upon electric-light carbons is not unreasonable, especially so in comparison with the classification for electrical fixtures and machinery. Yours truly,

"C. E. GILL,

"Chairman Official Classification Committee.

"July 27th, 1903."

EDITOR.

No. 253.—What is the best method by which to combat the "friendly feeling" among the three largest builders of electrical machinery?

There seems to be none yet discovered, in the majority of cases. Take your medicine and say nothing, is the best way, so far as I can learn at present. GEO. B. LAUDER.

We should say the only method to pursue would be to buy everything possible from the smaller concerns.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Having been employed by one of the "three largest builders of electrical machinery" for about 15 years, experience has taught me there is no need to "combat" that "friendly feeling," and I would suggest in answer to this question, as a remedy, "Pour oil on troubled waters." In other words, if you use them well, you will find they will do the same by you. The following were my instructions: "Use everybody right, politely, and alike." Therefore, let us attend to the electric-lighting and power business, and let them build their machinery, and, when they charge too much, build it yourself.

FRED. M. FRIEDBERG.

No. 254.—With very few exceptions, lightning will travel to station against direction of series current. What is the reason of this?

We have not found it so; but we would suggest that there was probably a ground on the positive side, close to the station, or some other local trouble.

To be frank, we have had very little time in which to find out which way lightning travels. Our experience has been that it generally does as it pleases unless you are using a first-class, time-tested arrester. We protect both lines of series circuits with choking coil of high inductance and low resistance, placing arresters on line side of coils. As yet we have not had lightning to pass this, and it becomes rather unpleasant in this section of the country in July and August. W. B. BLOXHAM.

Since we know nothing of where the lightning discharge originates, and since, as we generally encounter it in conductors, it is an alternating discharge, I presume that the question is intended to mean, Why is it that the leg of the circuit containing the series coil is the one damaged by lightning? This is altogether a matter of arrangement and of local conditions. If, for instance, we take a railway generator with the series coil on the trolley side of the system, it is obvious that any oscillating discharge affecting the line wire will tend to make its earth connection through the frame instead of through the windings of the machine, because of the inductance of the latter. This means in practice, since the series coil is nearest the line, that the lightning will spit off from the series coil to the frame in order to effect the required connection with the ground. If the series coil were included in the grounded leg of the circuit, the effects would probably be quite different. The disturbances, of course, reach us primarily, except in very few instances, through the overhead conducting system.

JOHN F. KELLY.

No. 255.—Why not request dealers in the far East of the United States always to send a net price list with advertisements sent to the extreme West of the United States, and thus avoid a season's delay?

As it takes six to eight days to get a letter from New York to the west of Oregon, it takes as long to get the answer back to New York. It takes six or eight weeks to get freight from the same place to the west of Oregon. Therefore, dealers who are advertising their wares fitted or adapted for the seasons, should in all cases give discounts or net prices.

All dealers, in sending advertisements to the electrical trade, should always give their net prices and terms. A person contemplating a purchase of material, say something new (which we are all looking for), will notice the advertisement, and, unless it is something extraordinary, will put the advertisement in the waste-basket rather than wait two weeks for an answer, by which time it is forgotten.

FRED. M. FRIEDBERG.

No. 256.—What bearing on the electrical industry and its operation has the employment of boys or young men of, say, eighteen, of no skill or experience; grammer-school graduates of limited education, with one or more years' experience in mechanical work of some kind?

We do not see that the electrical industry would differ from any other industry in this respect.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 257.—What is to be the result of the agitation throughout the country regarding municipalities entering the lighting business?

The report of the United States Government, as a result of its recent canvass of the electrical plants, should prove a valuable contribution to this subject. The agent, while at our place, said that he had great difficulty in getting the necessary data from nearly all the plants operated by municipalities, not because they desired to withhold it, but because they had no records, while the reverse was the case where plants were operated by private parties.

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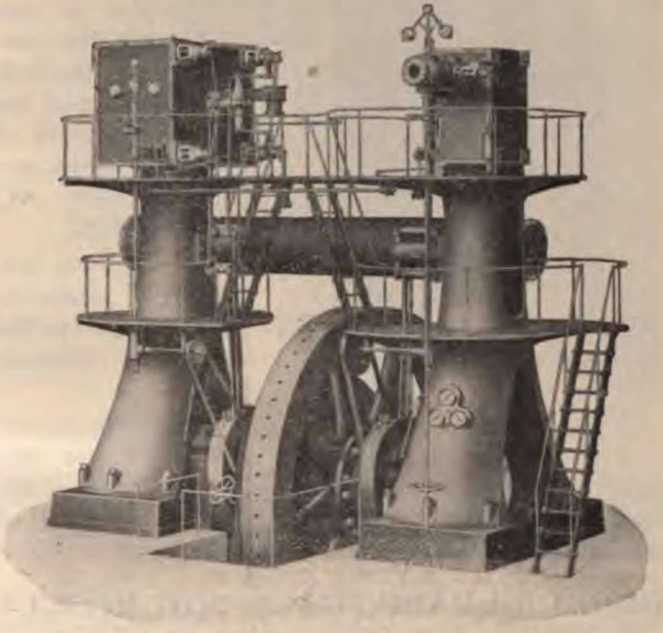

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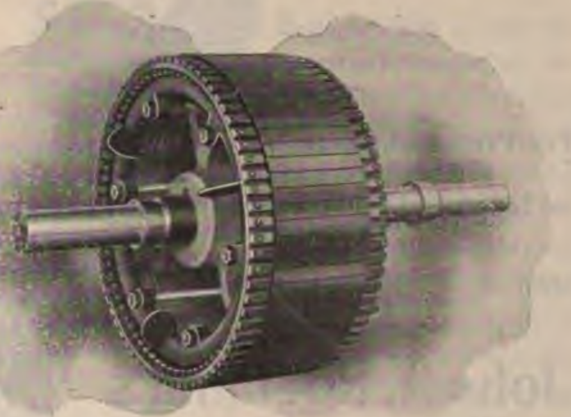

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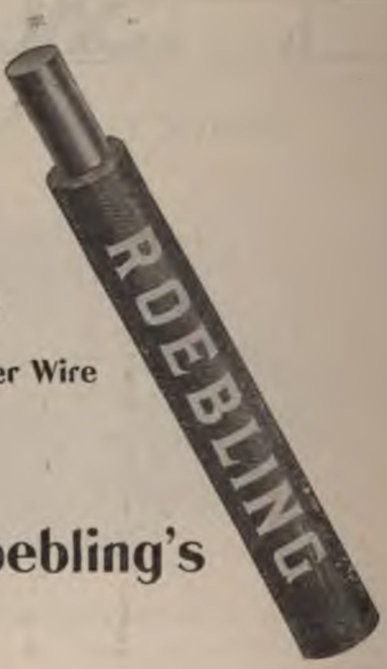

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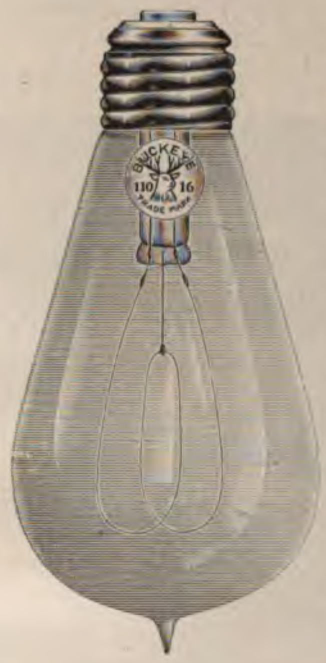

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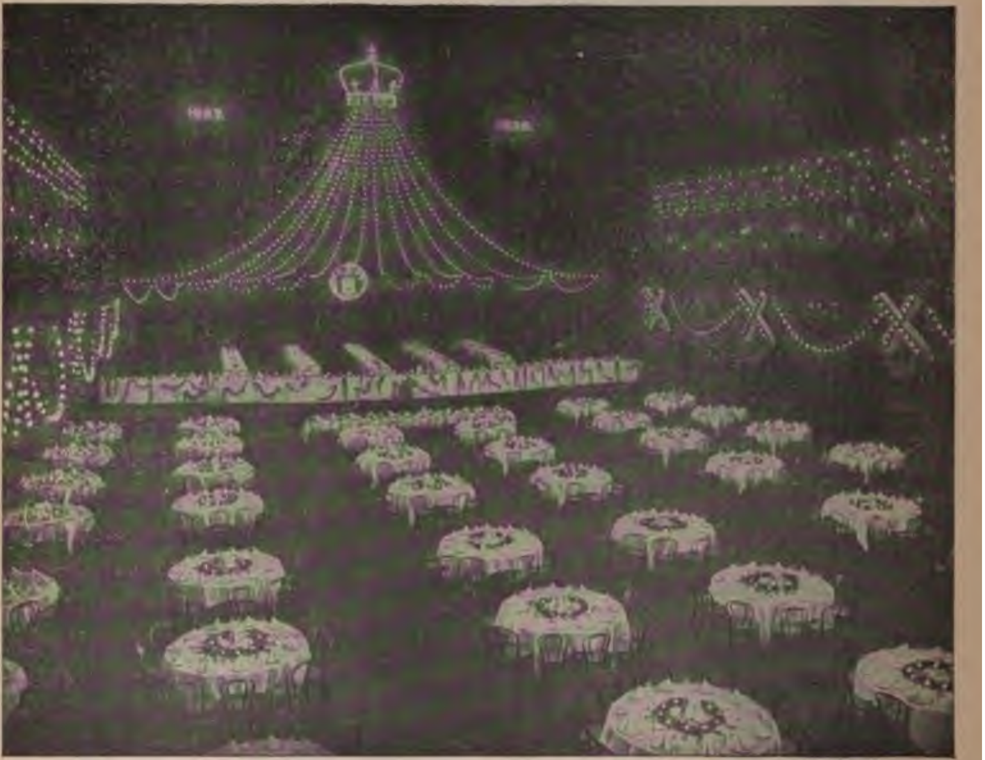

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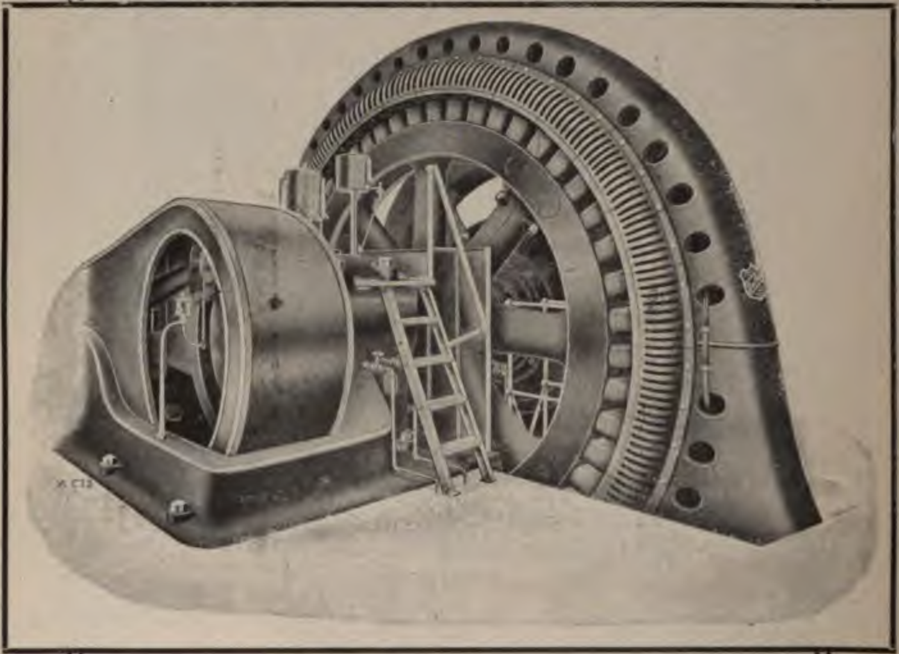

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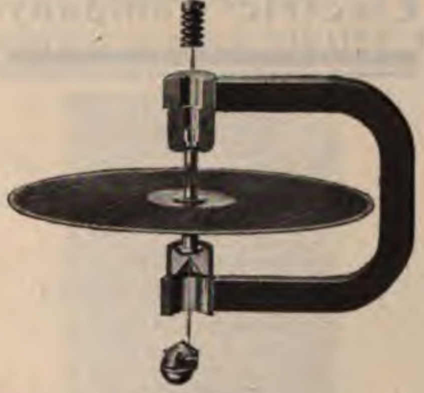

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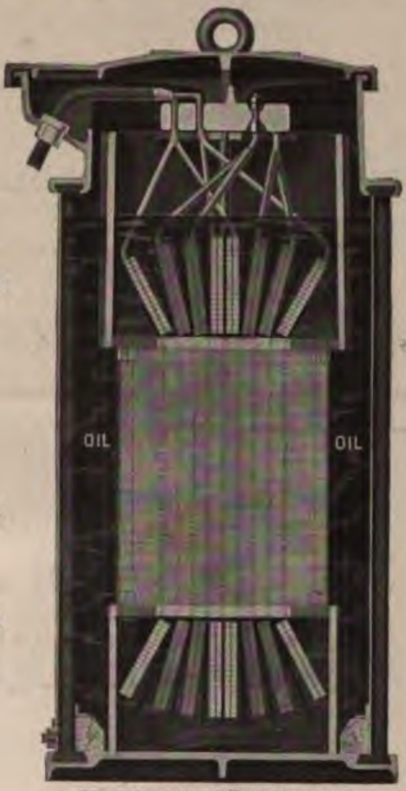

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